# OPERATION INSTRUCTIONS

## 4XXX SERIES THYRISTOR CONVERTERS FOR CONTROL OF DC MOTORS WITH INDEPENDENT EXCITATION FOR MAIN DRIVES

**ELL , Bulgaria**
ell@ell-bg.com http://www.ell-bg.com

## Table of contents:

# 1. General

4 XXX series converters are a new generation intelligent thyristor converters based on modern DSP / CPLD technologies. They are supplied directly by the power mains and provide double operation mode four-quadrant motor speed control. In the first operation mode the speed control process is performed by means of constant torque mode while in the second one – by means of constant power mode, and besides speed control mode the converters have position mode. All operation modes are set by means of parameter system.

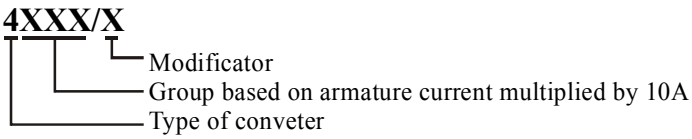
The thyristor converters of 4 XXX series are designated for universal function and could be built-in any machine, having high requirements for electrical drive system and besides this they have incorporated specific functions for main drive system of machines with CNC. They are in possession of interface providing different operation solutions for the customers.

## 2. Operation conditions, storage and transportation

- Ambient temperature - from 5° to 50° C
- Maximum relative humidity - 80 % at 30° C
- Altitude – not more than 1000m
- Environment - detonation safe, with no corrosive gas and vapour in concentrations provoking metal and insulation damages
- Keep indoors with no direct solar radiation
- Permissible vibrations with frequency between1 and 35 Hz and acceleration not more than 4,9 m / $s^2$

## 3. Technical data

Technical data of the converters are shown in **table 1**.




**Converter order number code**

**Modificator meaning:**

**"M" – converters designed at customer request. In this case individual technical features, interface and software are provided.**

**"R" – converters with power unit provided by customer – the dimensions are optional for each converter.**

| **Converter type:** | | **4002** | **4003** | **4004** | **4005** | **4006** | **4007** | **4009** | **4011** | **4013** | **4016** | **4020** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Rated armature current | **A** | 20 | 30 | 40 | 50 | 60 | 70 | 90 | 110 | 130 | 165 | 200 |
| Maximum armatute current | **A** | 40 | 60 | 80 | 100 | 120 | 140 | 180 | 220 | 260 | 335 | 400 |
| Input voltage | **V** | 3x380,+10/–15% | | | | | | | | | | |
| Input voltage frequency | **Hz** | 50/60 +/-2% | | | | | | | | | | |
| Maximum armature voltage of motor | **V** | 450 | | | | | | | | | | |
| Maximum field current of motor* | **A** | 10 | | | | | | | | | | |
| Speed dependent armature current limit | | Parameter settings | | | | | | | | | | |
| Maximum field voltage | | $320V_{=}$ at $U_{supp.}$= $380V_{AC}$ | | | | | | | | | | |
| Speed/position feedback sensor | | Tachogenerator or encoder/encoder | | | | | | | | | | |
| Speed reference | | Analog/ parallel code/ serial inerface | | | | | | | | | | |
| Position reference | | Parallel code/ serial inerface | | | | | | | | | | |
| Speed range | | 1:1000 | | | | | | | | | | |
| Stop in orientated position | | Built-in | | | | | | | | | | |
| Tachogenerator maximum voltage | **V** | +/-193 at $\mathbf{N_{MAX}}$ | | | | | | | | | | |
| Analog input | | +/- 10V / 0 to10V, 10 k | | | | | | | | | | |
| Analog outputs | | +/- 10V / 2 mA | | | | | | | | | | |
| Digital inputs | | 18 inputs, +/-24V / 10mA | | | | | | | | | | |
| Digital outputs** | | 5 relay outputs, $100V_{AC}$ / 0.3A, $24V_{DC}$ / 0.3A | | | | | | | | | | |
| Serial interfaces | | RS 232C to 9600 bps<br>RS 422 or RS 485 to 115 200 bps | | | | | | | | | | |
| Operation mode | | Continious S1 | | | | | | | | | | |
| Protection degree | | IP 20 | | | | | | | | | | |
| Dimensions H x W x L | **mm** | 405x200x170 | | | 405x200x195 | | | | 460x261x316.5 | | | |

**Table1.** Converter technical data

**Note:** * - the maximum field current is for standard converters. The maximum field current could be up to 25A at customer request;

** - both analog outputs are option that could be provided at customer request.

## 4. Construction and overall and fixing dimensions

The components of the 4XXX series converters are placed in a metal box. The mounting holes are on the upper and lower part of its back side. A radiator is mounted in the bottom of the box and the power elements are mounted on it. The pulse transformers, RC groups and fuses are installed above the power elements on a power board. The main board together with the interface terminals and indications are installed on the front panel. The overall and fixing dimensions and interface and power terminal locations are shown on **fig. 1**, **fig. 2** and **fig. 3**. The scheme of power board, on which pulse transformers and RC groups are installed, is shown on **fig. 4**. Scheme of power unit together with synchronizing transformers is shown on **fig. 5**.

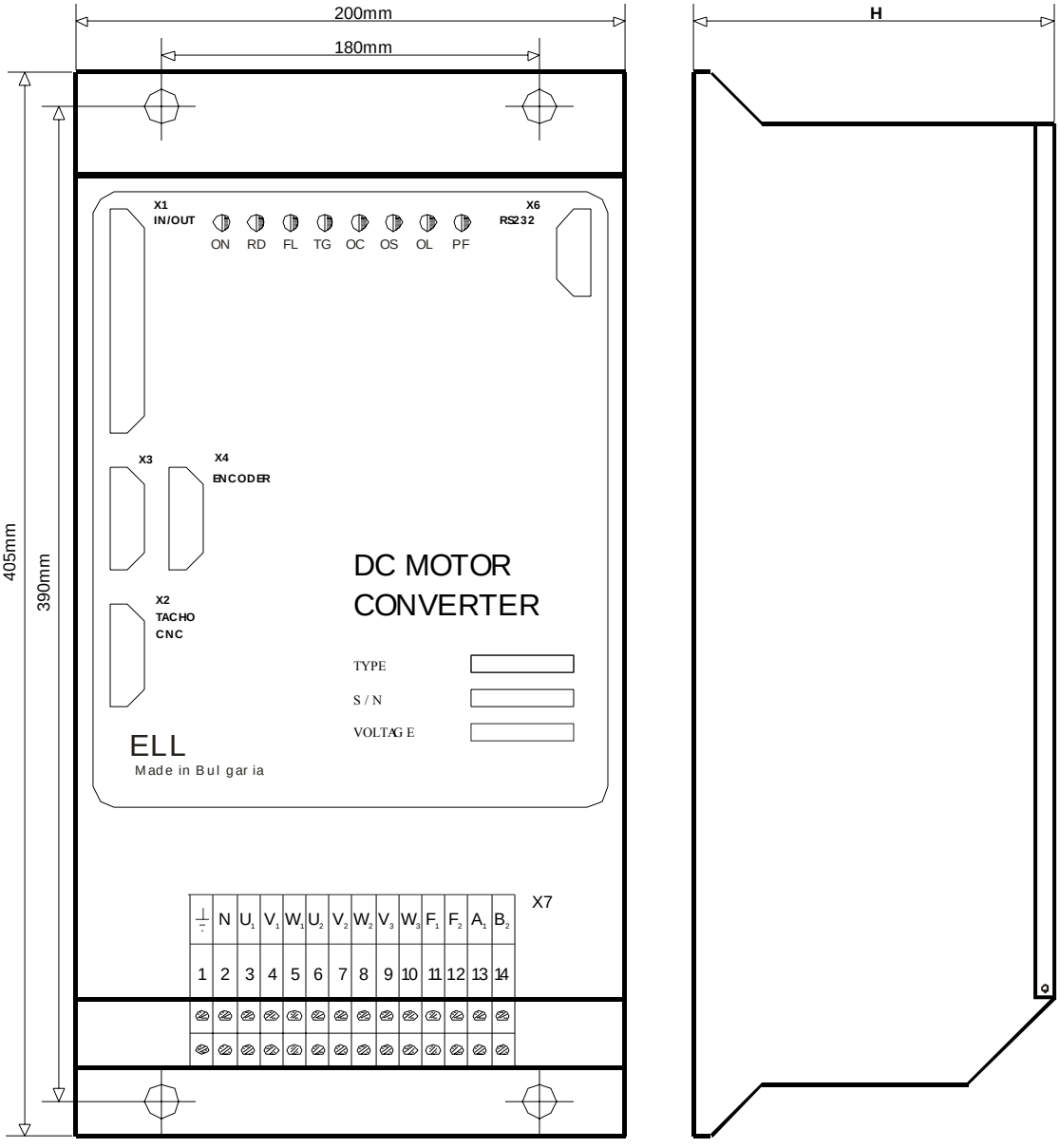



**Fig.1**. Overall and fixing dimensions of converters type 4002, 4003, 4004, 4005, 4006, 4007, 4009, 4011

**Note 1:** Size H for converters type 4002, 4003, 4004, 4005, 4006, 4007 - 170 mm.
Size H for converters type 4009, 4011 - 195 mm

**Note 2:** The X7 power terminal for converters type 4009, 4011 is shown on **fig. 2.**

X7

| N | $U_1$ | $V_1$ | $W_1$ | $U_2$ | $V_2$ | $W_2$ | $V_3$ | $W_3$ | $F_1$ | $F_2$ | $A_1$ | | $B_2$ | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |

**Fig. 2** X7 power terminal for converters type 4009 and 4011

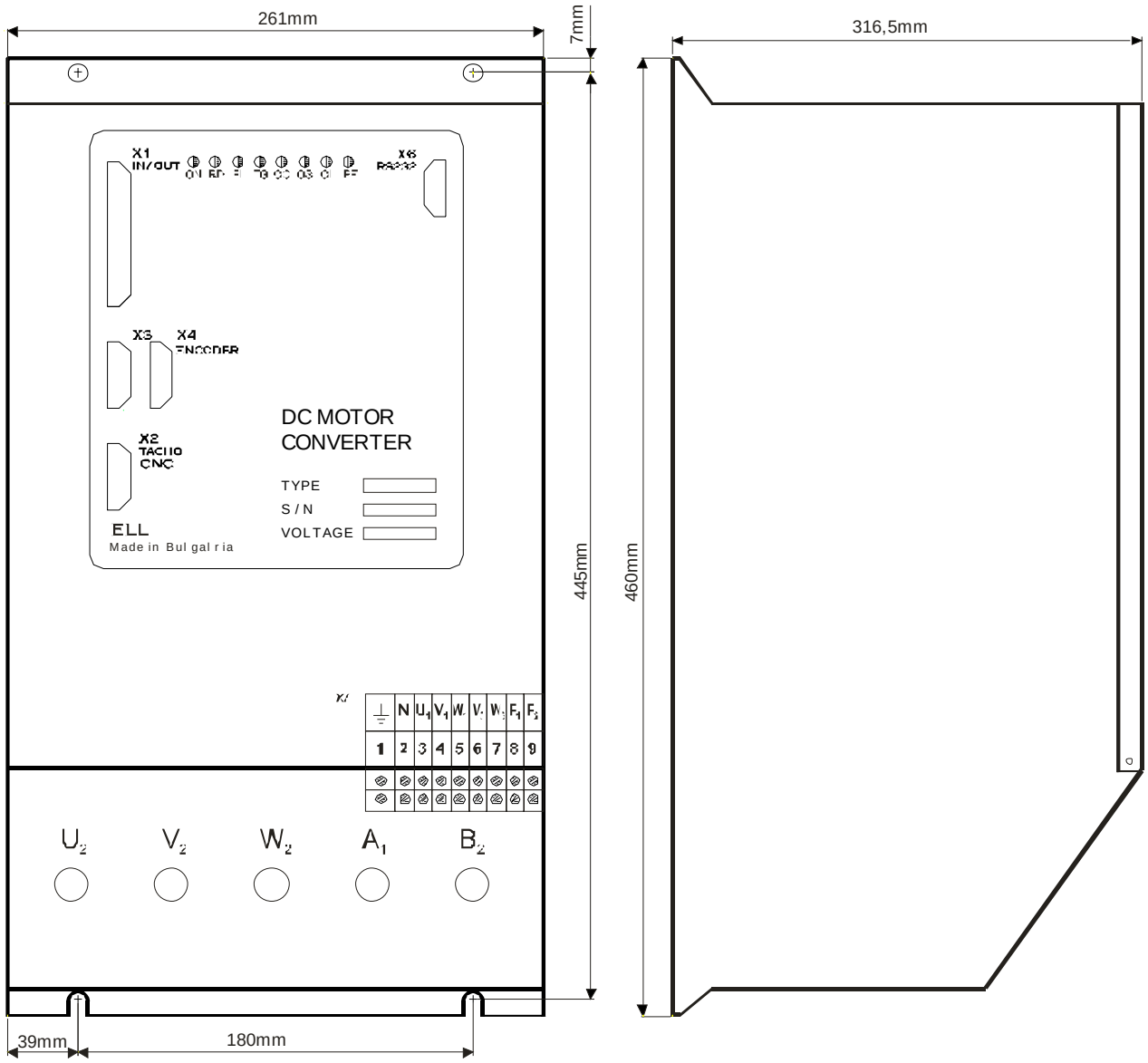



**Fig. 3** Overall and fixing dimensions for converters type 4013, 4016 and 4020.

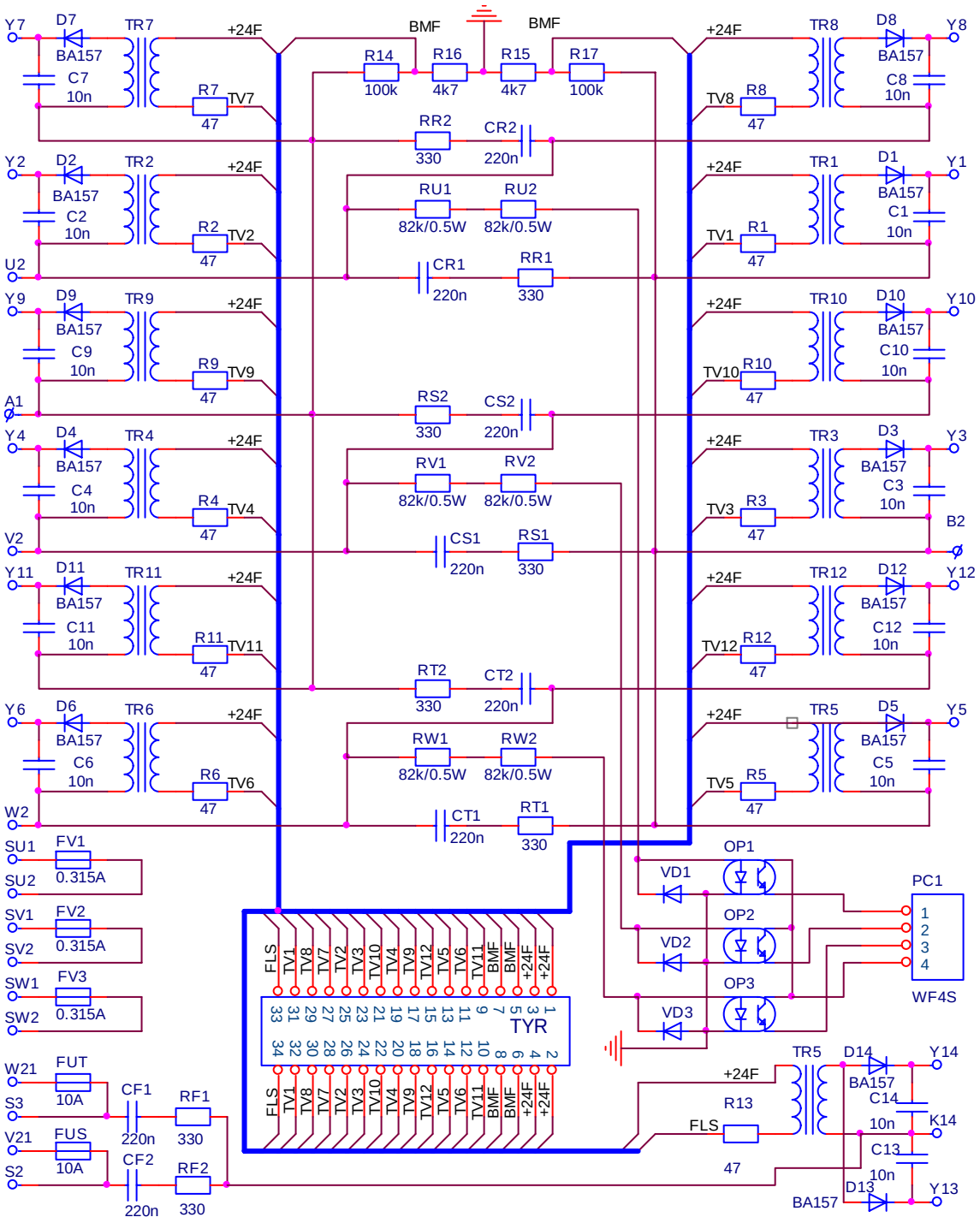



**Fig. 4** Scheme of power board with pulse transformers and RC groups

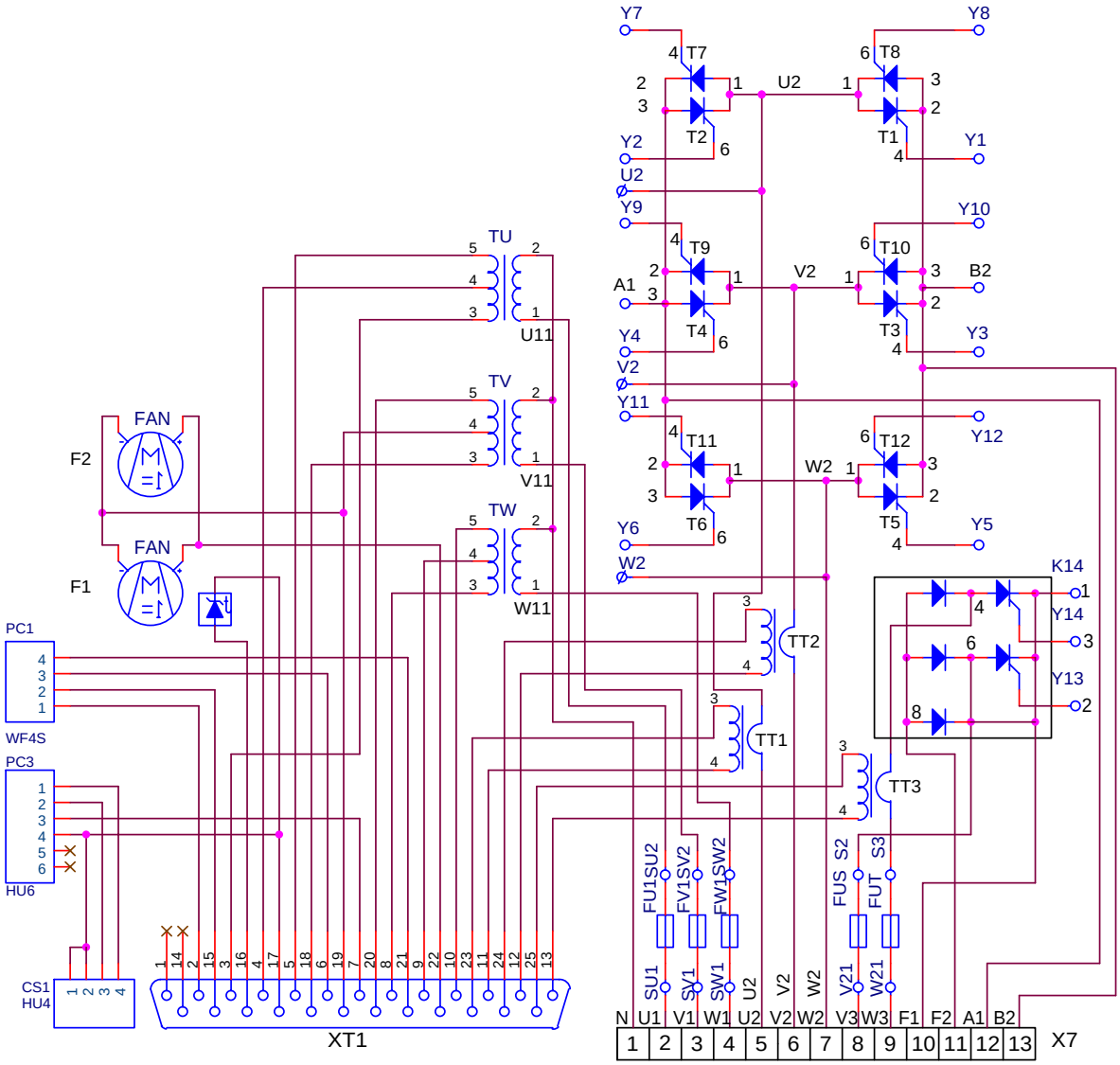



**Fig. 5** Scheme of power unit and synchronizing transformers

# 5. Interface and converter status indication

## 5.1. X1 parallel interface

The digital interface (**X1** connector) consists of:

- 12 digital inputs: from **IN1** to **IN12**, opto-isolated, for voltage of +/-24$V_{DC}$, input current not more than 10mA, low level of 0-7 V and high level of 13-30V. They are used for speed and position reference with parallel digital code;
- 6 digital inputs: **ON, SR, SF, ORCM, TLL** and **TLH**, opto-isolated, for voltage of +/-24$V_{DC}$, input current not more than 10mA and low level of 0-7V and high level of 13-30V. They are used for control of operation mode of the converter;
- 5 digital outputs: **RD, TL, ZS, SA** and **INPOS**, relay type, with load-carrying capacity of 0.3A at 100$V_{AC}$ and 0.3A at 24$V_{DC}$.They define the momentary status of the converter to the external control device.

A 37 pin connector X1 in the upper left part of the front panel is used for the digital interface. The pin location and the input structure are shown on **fig. 6**. The digital inputs are for universal function and could be selected by system outputs type **P** or **N**. Their supply could be performed by external voltage of 24 $V_{DC}$ or by the supply voltage of the converter.

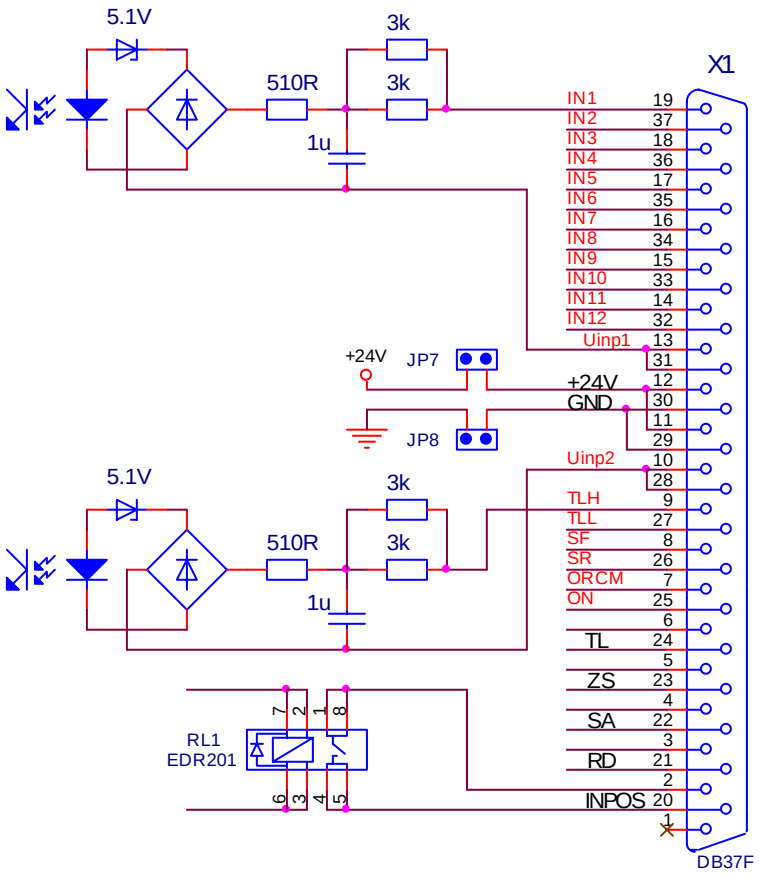
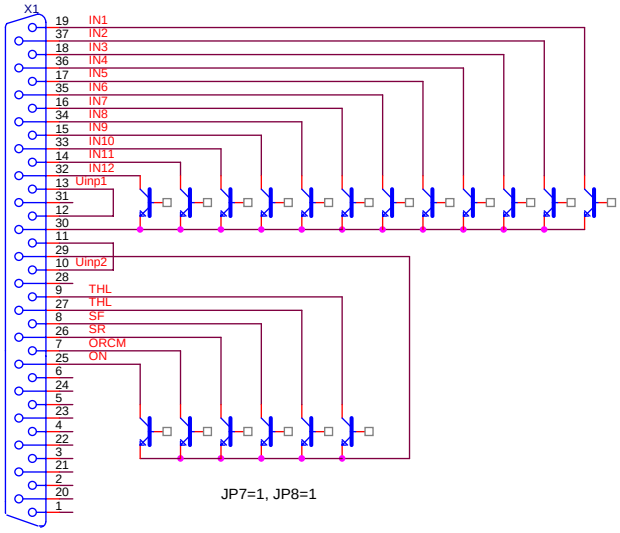


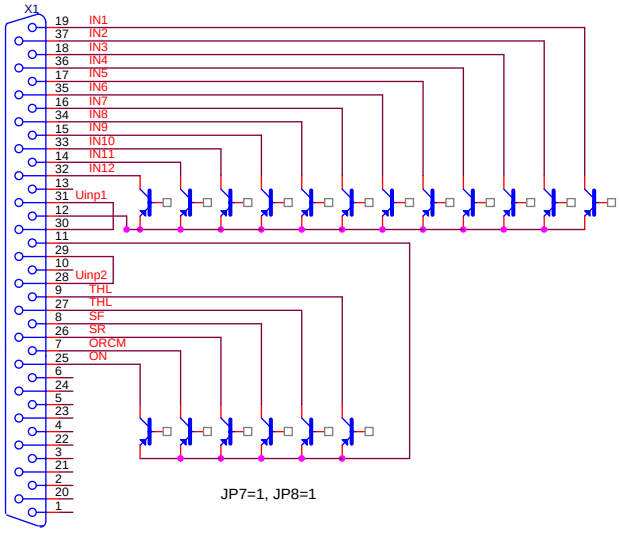

**Fig. 6** Pin location of X1connector and input/output structure

Connection alternative of the digital inputs are shown on **fig. 7**.



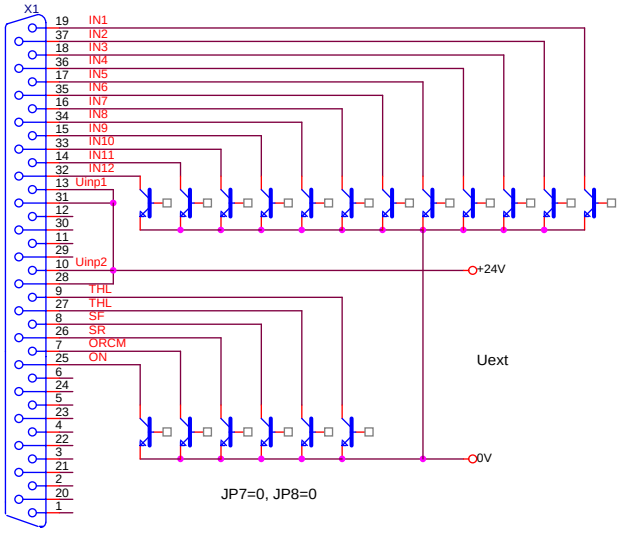

Alternative 1

All inputs are selected by system outputs type **N** with internal supply
(**JP7**=1, **JP8**=1)



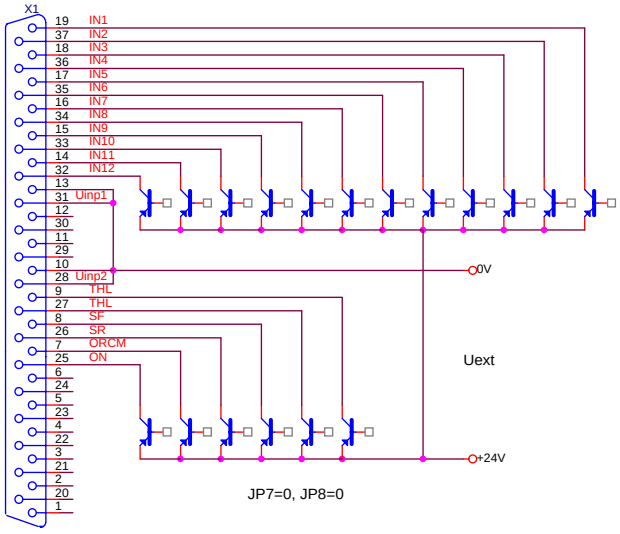

Alternative 2

All inputs are selected by system outputs type **P** with internal supply
(**JP7**=1, **JP8**=1)



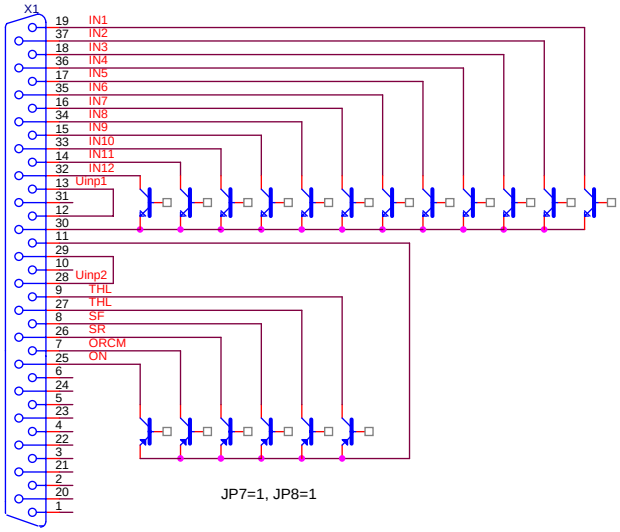

Alternative 3

All inputs are selected by system outputs type **N** with external supply
(**JP7**=**JP8**=0)



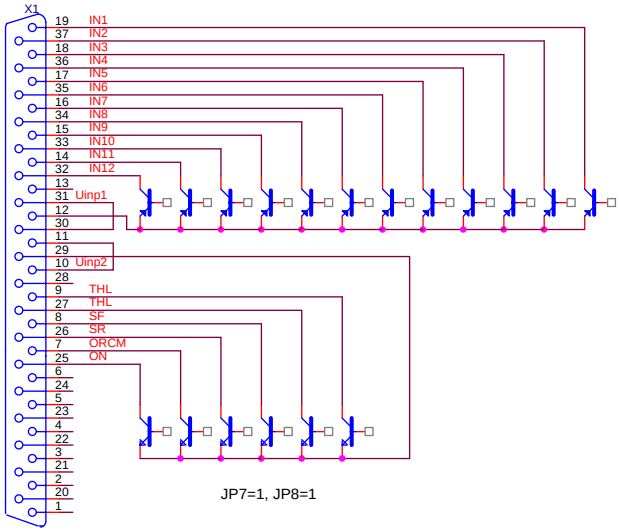

Alternative 4

All inputs are selected by system outputs type **P** with external supply
(**JP7**=**JP8**=0)



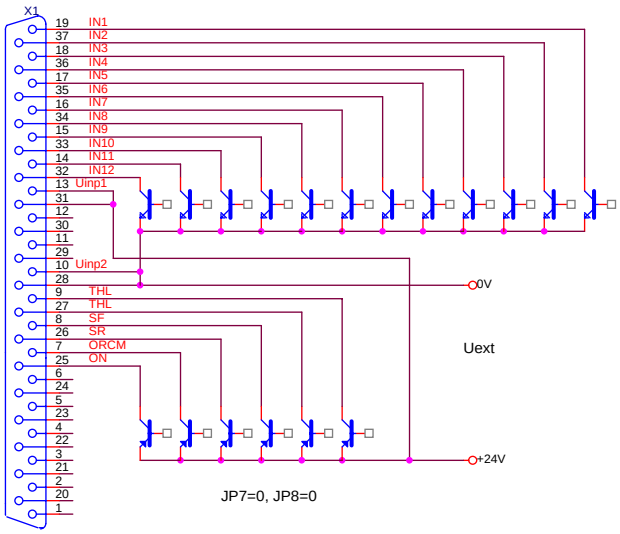

Alternative 5

The inputs from **IN1** to **IN12** are selected by system outputs type **N** and the other ones are selected by system outputs type **P**. All inputs are with internal supply
(**JP7**=1, **JP8**=1)



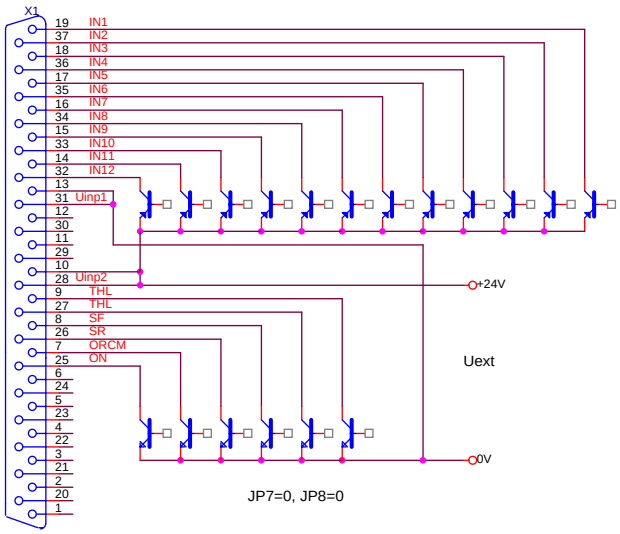

Alternative 6

The inputs from **IN1** to **IN12** are selected by system outputs type **P** and the other ones are selected by system outputs type **N**. All inputs are with internal supply
(**JP7**=1, **JP8**=1)




Alternative 7

The inputs from **IN1** to **IN12** are selected by system outputs type **N** and the other ones are selected by system outputs type **P**. All inputs are with external supply
(**JP7**=**JP8**=0)




Alternative 8

The inputs from **IN1** to **IN12** are selected by system outputs type **P** and the other ones are selected by system outputs type **N**. All inputs are fed by external supply
(**JP7**=**JP8**=0)

**Fig.7** Connection alternatives of digital inputs from **IN1** to **IN12**

### 5.1.1. Digital inputs

- from **IN1** to **IN12** (X1.14 to 19 and X1.32 to 37). They are used for:
  - speed reference with parallel digital code at **P28**=0;
  - position reference in oriented stop at **P84**=1. The oriented stop function is enabled by the user;
  - position reference in oriented stop at **P84**=1 and speed at **P28**=0. Before switching on **ORCM** signal the digital inputs from **IN1** to **IN12** are perceived as speed reference by the converter. After switching on ORCM signal the digital inputs from **IN1** to **IN12** are perceived as position reference in oriented stop function performance;
  - **OVERRIDE** function reference at **P90**=1 and **P28**= [1, 2] by means of digital inputs from **IN1** to **IN4**. The most bit of the reference is the signal of the highest number input. When reference is zero the **OVERRIDE** function performs the value of **P91,** and at maximum reference – the value of **P92**. Digital reference performance of the **OVERRIDE** function is shown on **fig. 8** where speed reference is analog at parameter **P28** = [1, 2]. Two alternatives are shown – with 8 and with 16 positions of reference.

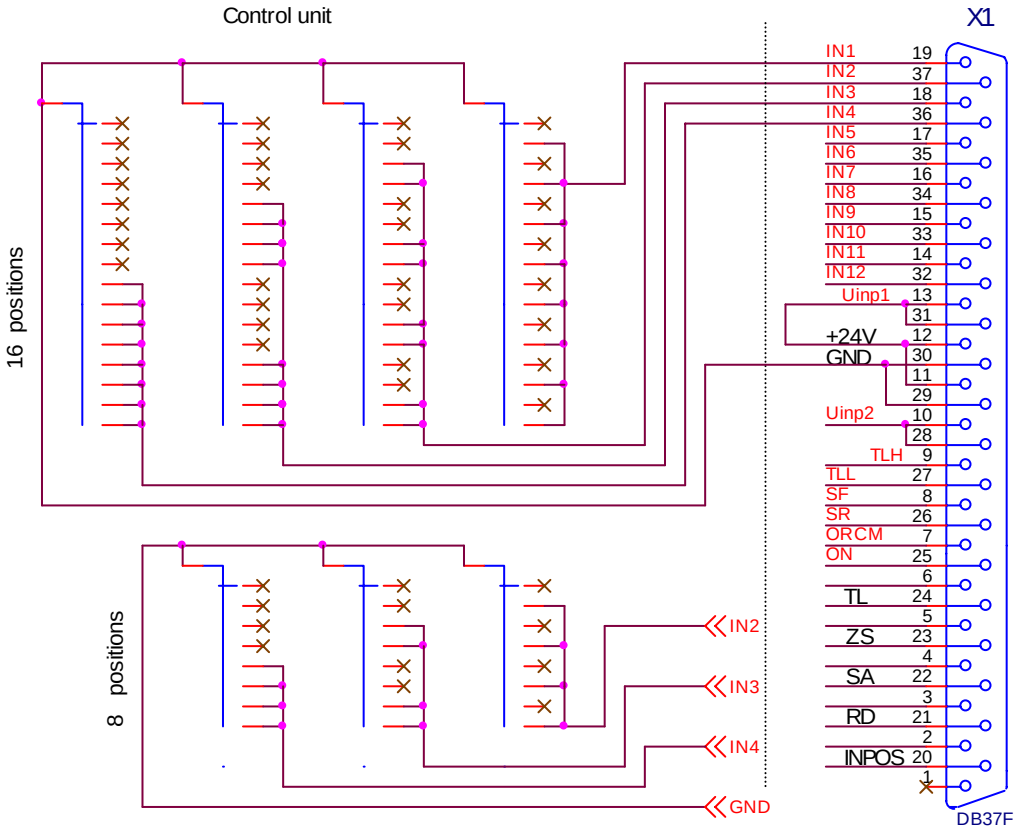



**Fig. 8** Alternatives of **OVERRIDE** function performance.

- **ON** (X1.25) – converter operation enabled. When this signal appears operation of the controllers is enabled, the power unit is activated and if there is no protection switched on the reference is performed. The **ON** command is performed only when speed is zero - **ZS**. Time-diagrams of command **ON** performance are shown on **fig. 9**.
- **SR** (X1.26) and **SF** (X1.8) – commands for control of motor rotation direction. They are used only when:
  - **P28**=0 – digital reference with parallel 12-bit code, entered in inputs from **IN1** to **IN12**.
  - **P28**=1 – analog unipolar reference with range from 0 to 10V;

  When commands **SF** and **SR** are active together, zero speed reference is performed;

- **ORCM** (X1.7) – oriented stop. At **ORCM** command the rotation speed is set at the so-called "speed of search". After registration of zero pulse from encoder the motor stops in position defined with parallel code by **IN1** to **IN12** at **P84**=1 or with the value of parameter **P39** at **P84**=0.
- **TLL** (X1.27) – limitation of the torque - low. At **TLL** command the torque of the motor is limited up to the value of **P46** parameter in range of 1% to 100% from the rated motor current $\mathbf{Ia_{NOM}}$ (**P43**);
- **TLH** – (X1.9) – limitation of the torque - high. At **THL** command the torque of the motor is limited up to the value of **P45** parameter in the range of 10% to 100% from rated motor current $\mathbf{Ia_{NOM}}$ (**P43**).

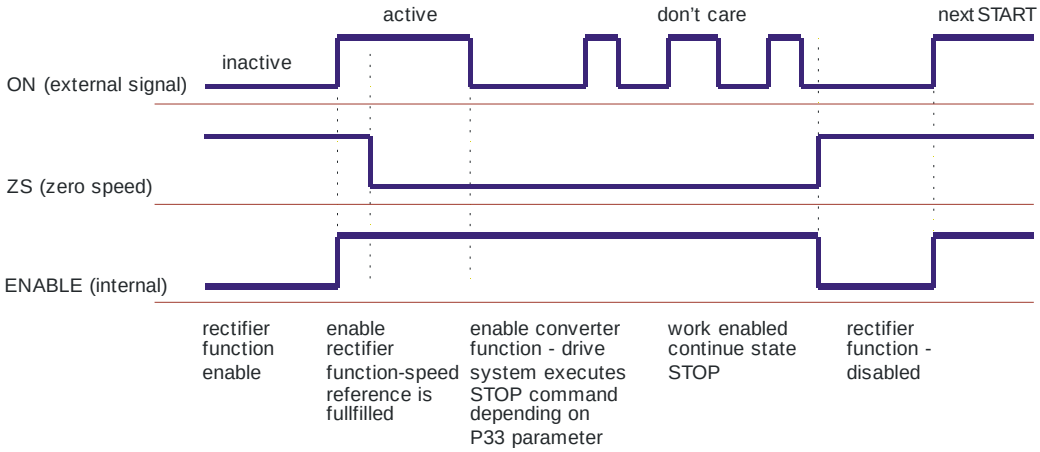



**Fig. 9** Time-diagram of **ON** signal and internal operation enabling

### 5.1.2. Digital outputs

- **RD** (X1.3, X1.21) – ready. It becomes active approximately 2 seconds after the converter is supplied by the supply voltage and if there is no any protection signal appeared;
- **TL** (X1.6, X1.24) – torque limit. It becomes active when the converter is operating in torque limit mode by the external commands **TLL** or **TLH**;
- **ZS** (X1.5, X1.23) – zero speed. It becomes active at rotation speeds under the speed set by the value of **P23** parameter;
- **SA** (X1.4, X1.22) – speed arrival. It becomes active at rotation speed above the speed set by the value of **P24** parameter;
- **INPOS** (X1.2, X1.20) - stop in position. It is activated in oriented stop mode when the set position is reached in the limits set by the value of **P36** parameter.

## 5.2. Analog interface – X2

The analog interface (**X2** connector) is shown on **fig. 10** and it consists of:

- differential analog input;
- analogue input of speed feedback in tachogenerator operation;
- 2 programmable analog outputs.

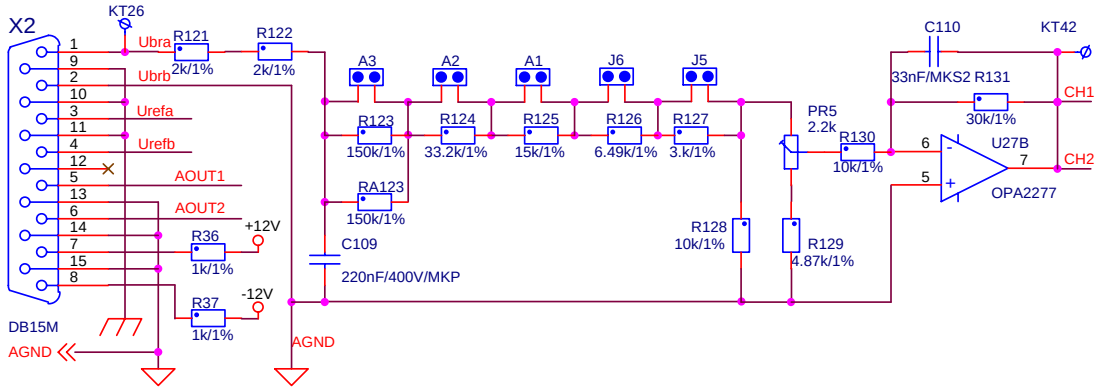



**Fig. 10** Scheme of the analog interface and location of the signals of **X2** connector

### 5.2.1. Differential analog input

The differential analog input **Urefa** (X2.3) and **Urefb** (X2.4) is used for speed control by analog control signal at values of parameter **P28**=1 or **P28**=2.

When parameter **P90**=1 the analog control signal is used for reference of **OVERRIDE** function. In this case of realization of **OVERRIDE** function, shown on **fig. 11**, the speed reference is performed with parallel code of the digital inputs **IN1** to **IN12** at parameter **P28**=0 or through serial interface at parameter **P28**=3.

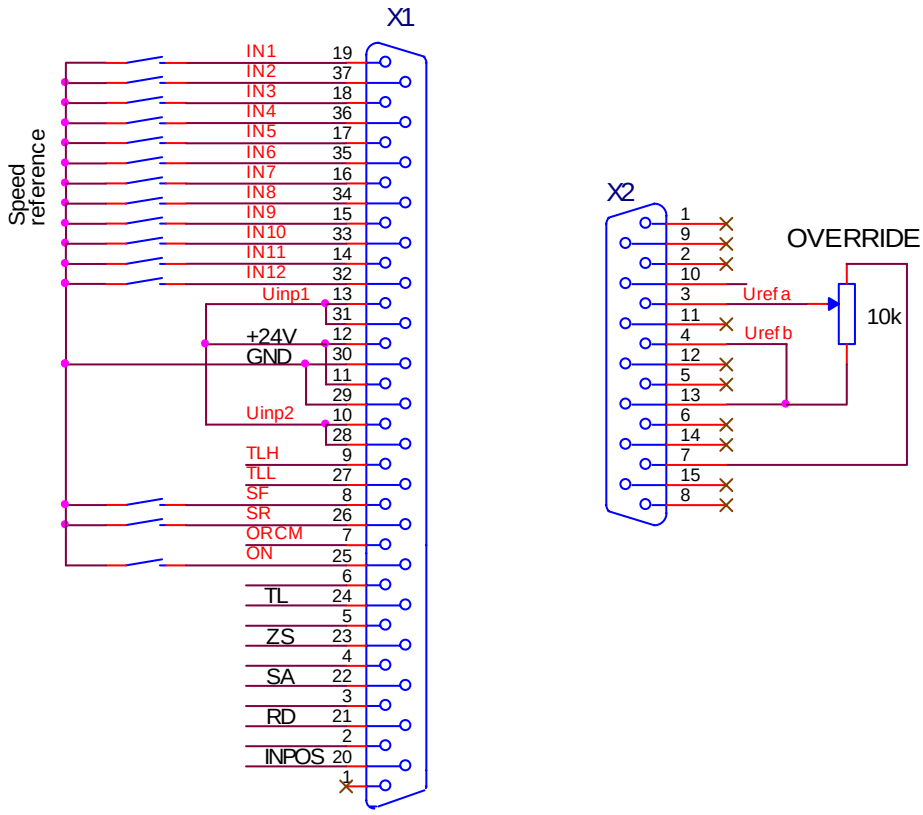



**Fig. 11** Analog alternative of OVERRIDE function

### 5.2.2. Analog input for tachogenerator

The analog input for tachogenerator **Ubra** (X2.1) and **Ubrb** (X2.2) is used when the speed feedback sensor is tachogenerator. The scheme of the analog unit of speed feedback channel with tachogenerator is shown on **fig. 10**.

The change of speed feedback coefficient is performed by means of jumpers **A1, A2, A3, J5** and **J6** (located on the main board – **fig. 18**) The location of the jumpers for different ranges of tachogenerator voltage at maximum speed is shown on **table 2**. The fine tuning of the speed feedback coefficient at maximum speed is performed by **RP5** trimmer – **fig. 18**.

| № | J6 | J5 | A1 | A2 | A3 | Ubrmax[V] RP5counter clockwise | Ubrmax[V] RP5 clockwise |
|---|---|---|---|---|---|---|---|
| 1 | ■ | ■ | ■ | ■ | ■ | 7.0 | 10.3 |
| 2 | | ■ | ■ | ■ | ■ | 10 | 14.5 |
| 3 | ■ | | ■ | ■ | ■ | 13.5 | 19.0 |
| 4 | | | ■ | ■ | ■ | 17.5 | 23 |
| 5 | ■ | ■ | | ■ | ■ | 22 | 30 |
| 6 | ■ | | | ■ | ■ | 28.5 | 39 |
| 7 | | | | ■ | ■ | 31.5 | 44 |
| 8 | ■ | ■ | ■ | | ■ | 40 | 56 |
| 9 | ■ | | ■ | | ■ | 48 | 63 |
| 10 | ■ | ■ | | | ■ | 57 | 74 |
| 11 | | | | | ■ | 66 | 90 |
| 12 | | ■ | ■ | ■ | | 86 | 114 |
| 13 | | ■ | | ■ | | 105 | 130 |
| 14 | | ■ | ■ | | | 123 | 157 |
| 15 | | | | | | 150 | 193 |

**Table 2** Tachogenerator voltage at maximum speed and maximum speed reference
**Note:** The dark fields show a closed jumper.

### 5.2.3. Analog outputs

Both analog outputs are option that could be assembled at customer request.

- **AOUT1** (X2.5) – analog output with range +/- 10 V referred to analog ground **AGND** (X2.13, X2.14 and X2.15) and permissible current capability 2 mA. The signal of the analog output **AOUT1** corresponds to the variable, selected by **P88** parameter;
- **AOUT2** (X2.6) – analog output with range +/- 10 V referred to analog ground **AGND** (X2.13, X2.14 and X2.15) and permissible current capability 2 mA. The signal of the analog output; **AOUT2** corresponds to the variable, selected by **P89** parameter.

### 5.2.4. Others

- **AGND** (X2.2, 13, 14, 15) – analog ground. It is common for all output and input analog signals.
- **+12 V** (X2.7) and **–12 V** (X2.8) –internal converter voltages for motor speed control by means of potentiometer, as shown on **fig. 17**.
- **EARTH** (X2.9, 10, 11) - the metal box of the converter.

## 5.3. Serial interface – X6

The serial interface is standard RS 232 C with speed of communication of 9600 bps. It is 9 - pin male connector (X6) in the upper side of the front panel. +5V voltage used for supplying of the specialized terminal is on X6.9. The pin location is shown on **fig. 12**.

RS 485 and RS 422 serial interfaces are optional.

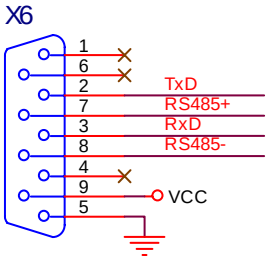



**Fig.12** Scheme and location of serial interface pins

## 5.4. X3 and X4 encoder input

The encoder input is a 15 pins female connector, located in the lower left part of the front panel. The scheme of the input unit and the location of the pins are shown on **fig. 13**. The X4 connector is an extension of X3 connector and allows another device to have access to the encoder signals.

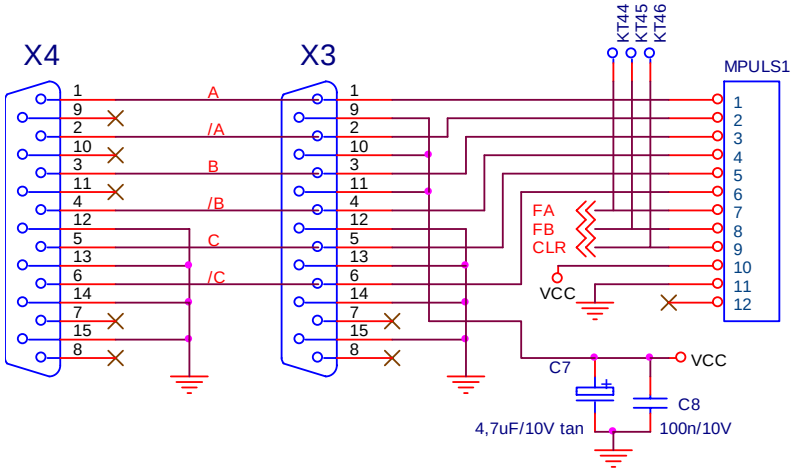



**Fig. 13** Scheme and location of the pins on the input for the encoder

## 5.5. Converter status indication

There are 8 LED-s on the upper side of the front panel. They indicate the momentary status of the converter. The blinking of each of them shows normal operation mode or failure situation.

The indications of the converter status are as follows:

**ON** – operation enable;

**RD** – the converter is ready for operation;

**FL** – failure mode. The current in the excitation winding does not correspond to the reference values;

**TG** – failure mode. Incorrect connection, short circuit or circuit brake of speed feedback;

**OC** – failure mode. The current of the motor armature exceeds the permissible reference value or there is short circuit in converter power rectifier;

**OS** – failure mode. The maximum reference value of motor rotation is exceeded;

**OL** – failure mode. **$I^2t$** protection signal appeared or there is overheating in converter power unit;

**PF** – failure mode. Brake or bad line connection of supply voltage. There is bad earthing of the converter.

# 6. Installation

The converters of 4XXX series as well as the commuttating and protective components that belong to the set of the electrical drive are assembled in a box. When assembling the following rules must be taken into consideration:

- The converter must be mounted in vertical position. The mounting must be done by bolts in the relevant mounting holes, located in the upper and the lower part of the box.
- There must be at least 100 mm free space over and under the converter, providing vertical air circulation through the radiator of the power units.
- Cables must be as short as possible.
- Do not mount the signal conductors close to the power cables.
- Connection of the analog signals must be done by means of a shielded cable and the shield must be grounded in one end only. The shield must be connected to X2.9, X2.10 and X2.11. Do not use the shield of the cable as a current conductor.
- Observe the protective element values and types, shown in **table 4** and the minimum cross section of the connecting conductors according to **fig. 17.**
- The electrical connections must be performed according to the scheme of **fig. 17.**

| | **4002 / 4003** | **4004 / 4005** | **4006 / 4007** | **4009 / 4011** | **4013 / 4016** | **40020** |
|---|---|---|---|---|---|---|
| TC1 | 4 $mm^2$ | 6 $mm^2$ | 10 $mm^2$ | 2x10 $mm^2$ | 25 $mm^2$ | 35 $mm^2$ |
| TC2 | 4 $mm^2$ | 4 $mm^2$ | 6 $mm^2$ | 10 $mm^2$ | 16 $mm^2$ | 25 $mm^2$ |
| TC3 | 4 $mm^2$ | 6 $mm^2$ | 10 $mm^2$ | 16 $mm^2$ | 16 $mm^2$ | 16 $mm^2$ |
| TC4 | 4 $mm^2$ | 4 $mm^2$ | 6 $mm^2$ | 10 $mm^2$ | 10 $mm^2$ | 10 $mm^2$ |
| TC5 | 2.5$mm^2$ | | | | | |
| TC6 | 1.00$mm^2$ | | | | | |
| TC7 | Shield + 3x3 + 2x0.35$mm^2$ | | | | | |
| TC8 | Shield + 2x0.35$mm^2$ | | | | | |
| Choke | PK 0525 | PK 0584 | PK 02612 | PK 02715 | PK 021632 | PK 022550 |
| FQ1-Automatic breakers Schneider Electric Catalogue № | C60ND 24602-16A / 24604-25A | C60ND 24620-32A / 24621-40A | C60ND 24623-50A / 24624-63A | C120ND 18387-80A / 18388-100A | Compact NB 31604-125A/ 31603-150A | Compact NB 31602-175A |
| FUS and FUT fuses | 10A | | | | | |
| FU, FVand FW fuses | 0.315A | | | | | |

**Table 3** Minimum cross sections of the connecting conductors, types and values of the protective elements

**Note**:It is permissible to use devices of other manufacturers but with the same features.

It is permissible to use other chokes with inductance not less than 0.2mH and providing normal operation at the rated and at the maximum currents of the motor.

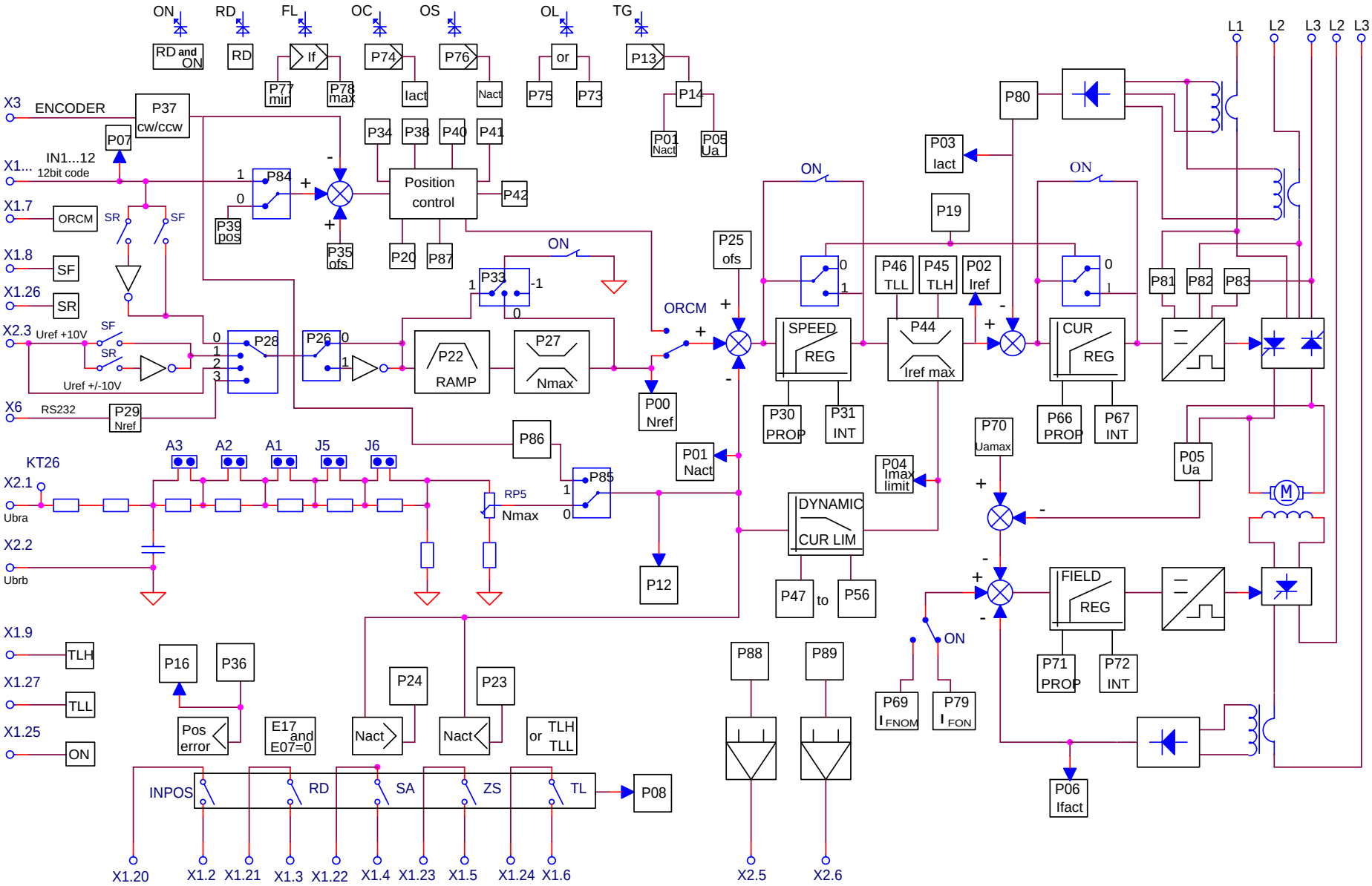



**Fig.14** Function scheme

# 7. Converter setting

The scheme of parameters is shown on fig. 14.

The settings are performed in two manners: with specialized terminal connected to the serial interface (**X6**) or with personal computer.

**ATTENTION!**

**The connection/disconnection of the specialized terminal or of the personal computer to RS 232(X6) must be performed only when the supplies to the converter are switched OFF.**

## 7.1 Specialized terminal or PC operation

Converter setting is done by a specialized terminal connected to the serial interface. System of parameters, whose values specify the operation of the separate function units, motor parameters, limits of operation of the unit for protections, and the output signals giving information for converter status are set in the nonvolatile memory. During operation on display, the values of all parameters concerning motor and converter operation can be indicated, and they together with the LED indication in the upper part of the front panel could give full information about parameter status in any moment.

When the supply voltage is switched ON the sign **P00** appears on LED display. The letter **P** means that the chosen parameter has a number that is presented by its last two digits. The choice of a parameter as well as the change of its value is performed by means of the buttons, situated under the LED display and having the following superscriptions:

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **ESC** | **UP** | **DOWN** | **ENTER** | **or their symbols** | **ESC** | ⇑ | ⇓ | ⏎ |

By pushing **UP** and **DOWN** buttons you can move up and down in the parameter list. By pushing ENTER button (entering in "setting parameter mode)" the value of the chosen parameter is shown. The change of this value could be made in the same way as the change of parameter number. The chosen value is recorded in the memory by pushing **ENTER** button. By pushing **ESC** button you return to "Parameter choice mode". In case you change a parameter value and you do not confirm your choice by pushing ENTER button, this changed new value will not be recorded if you push ESC button. When changing parameter value and push and hold the **UP** or **DOWN** button for period during which more than 20 dimensionless units of a decimal range are changed, the change of the higher decimal range begins. When stop pushing the button this mode becomes inactivate.

The converter can also operate by terminal program for personal computer (e.g. TERM95. exe from NORTON COMMANDER). The serial interface (COM 1 or COM 2 of the computer) must be set at 9600bps, 8N1, terminal emulation ANSI. There are 4 buttons that are in use and their function is identical to the functions of the specialized terminal:

**"o" – ESCAPE "u" – UP, "d"- DOWN, "e" - ENTER**

When choosing a parameter, the parameter number together with text described in the third column of table 5 appear on the firs row. The value of the parameter is shown on the second row. The changes are done in the mentioned above way.

While working with terminal program you have to use small letters /Caps Lock button must be inactivated/. If you use capital letters /Caps Lock button is activated/ the protocol serving the specialized terminal is activated (the values are displayed in HEX (hexadecimal) representation format and there is no text displayed). Push any of the 4 buttons (in "small letters mode") mentioned above to return to personal computer mode.

## 7.2 Converter parameters

The parameters of the converter are divided into 6 relative groups:

**Group 1** – parameters that show the values of the controlling signals and the signals coming from and going to the motor. In this group the values of the current in the excitation and armature windings, the rotation speed, armature voltage, and the output and input status are included. These values are read – only;

**Group 2** – system parameters concerning the access to non-volatile memory;

**Group 3** – parameters for speed control. In this group the parameters concerning speed controller coefficient, oriented stop and operation of digital inputs and outputs are included. These parameters concern the speed control;

**Group 4** – current control parameters. Besides coefficients of field and armature current controllers in this group the parameters concerning the speed dependent current limit and torque limit of the motor by external signal commands are included;

**Group 5** – protection parameters defining limits and controlled signals;

**Group 6** – configuration parameters enabling setting of the converter in relation with the power supply mains and the external operation devices;

**Parameters list is shown on table 4.**

Besides the parameters, the information for errors resulting of changing the value of relevant parameters in illegal mode or of converter operation is shown on the display. When an **EXX** message appears, it means that an error, whose number is shown in the last two digits, occurred. When the error is registered the error message appears with no matter of the converter operation mode and without any further actions performed by the user. By pushing **ESC** button the state preceding the error is restored. Error list is shown on **table 5** and **table 6** the error list and the LED display status are shown.

**Attention!**

**When you switch the inverter ON for the first time and error message E07 appears together with OS LED blinking on the front panel, this means that the error is in the parameters recorded in the nonvolatile memory. It is necessary the default value to be restored and if there are any changes they must be recorded again. In case this E07 error appears again it is necessary the nonvolatile memory to be replaced. If the LED display does not flash when turning the supply of the converter on, this means that there is a damage in the control unit. Switch off the power supply and contact the authorized servicing company.**

| Par.No | Parameter, name | Text string | Limits |
|---|---|---|---|
| P00 | Speed reference | Vel ref | % $N_{MAX}$ |
| P01 | Actual speed | Vel actual | % $N_{MAX}$ |
| P02 | Armature current reference | Current ref | % $Ia_{NOM}$ |
| P03 | Actual armature current | Current act | % $Ia_{NOM}$ |
| P04 | Speed dependent current limit - actual | Curr limit | % $Ia_{NOM}$ |
| P05 | Armature voltage | Voltage | - |
| P06 | Field current indication | Field curr | - |
| P07 | Digital inputs status | DIGIT INPUT | - |
| P08 | Digital outputs status | DIGIT OUTPUT | - |
| P09 | Reserved | Reserve | - |
| P10 | Converter version No | Version DRV | - |
| P11 | Reserved | Reserve | - |
| P12 | Speed feedback test | Test tacho | % ripple |
| P13 | Running error of protection of speed feedback loss | Error TGprot | - |

| | | | |
|---|---|---|---|
| P14 | Proportional coefficient between actual speed and armature voltage (in first operating mode only) | Armatur cnst | 0.10 to 10.00 |
| P15 | Password | Usr password | -999 to 9999 |
| P16 | Actual error value at **ORCM** | Error POS | - |
| P17 | Default values loading | Default load | 0, 1 |
| P18 | Reserved | Reserve | - |
| P19 | Switching speed and current controllers off | Bypass PIDs | 0, 1 |
| P20 | Offset speed reference at **ORCM** | Ofst pos spd | -80 to 80 |
| P21 | Reserved | Reserve | - |
| P22 | Rampgenerator time | Ramp time | 0 to 20.0 s |
| P23 | Threshold of speed $\mathbf{N_{ZS}}$ under which **ZS** switches on | Level of ZS | 0.5 to 3.0 $\%N_{MAX}$ |
| P24 | Threshold of speed $\mathbf{N_{SA}}$ over which **SA** switches on | Level of SA | 70.0 to95.0 $\%N_{REF}$ |
| P25 | Offset setting of speed reference | Offset speed | +/-5.0% $N_{MAX}$ |
| P26 | Change of speed reference sign | Change sign | 0, 1 |
| P27 | Motor speed limit reference | Max vel ref | 0 to100.0 % $N_{MAX}$ |
| P28 | Selection of control signal reference | Source ref | 0, 1, 2, 3 |
| P29 | Speed reference when **P28**=3 | Dig vel ref | +/-100.0 % $N_{MAX}$ |
| P30 | Speed regulator gain | P spd cntrlr | 1 to 100 |
| P31 | Speed regulator time constant | I spd cntrlr | 0 to 400ms |
| P32 | Reserved | Reserve | - |
| P33 | Emergency stop | Fast halt | -1, 0, 1 |
| P34 | Encoder-pulses per revolution | Encoder | 500 to 2 500 |
| P35 | Position reference offset at **ORCM** | Offset POS | 0 to 4 095 |
| P36 | Permissible variation from reference position in which digital output **INPOS** switches on | INPOS level | 0 to 63 |
| P37 | Change of encoder phases | Encoder phs | 0, 1 |
| P38 | Coefficient between spindle speed of rotation and encoder speed of rotation | Reduction | 0.100 to 8.000 |
| P39 | Position reference in oriented stop position | Position | 0 to 4 095 |
| P40 | K1 coefficient of position controller | POS cntrlr 1 | 0.000 to 0.500 |
| P41 | K2 coefficient of position controller | POS cntrlr 2 | 0.50 to 16.00 |
| P42 | K3 coefficient of position controller | POS cntrlr 3 | 0.50 to 16.00 |
| P43 | Rated current of motor $\mathbf{Ia_{NOM}}$ | Current NOM | 1 to 100%$Idrv_{NOM}$ |
| P44 | Maximum current of motor $\mathbf{Ia_{MAX}}$ | Current MAX | 1 to 200% $Ia_{NOM}$. |
| P45 | Maximum current of motor $\mathbf{Ia_{TLH}}$ at **TLH** signal | Level of TLH | 10 to 100% $Ia_{NOM}$ |
| P46 | Maximum current of motor $\mathbf{Ia_{TLL}}$ at **TLL** signal | Level of TLL | 1 to 100% $Ia_{NOM}$ |
| P47 | Limit speed $\mathbf{N_{L1}}$ at $\mathbf{Ia_{MAX}}$ | Vel point 1 | 1 to P49 |
| P48 | Limit current $\mathbf{Ia_{L6}}$ at $\mathbf{N_{MAX}}$ | Curr point 6 | 1 to P56 |
| P49 | Speed at point 2 | Vel point 2 | P47 to P51 |
| P50 | Armature current at point 2 | Curr point 2 | P52 to P44 |
| P51 | Speed at point 3 | Vel point 3 | P49 to P53 |
| P52 | Armature current at point 3 | Curr point 3 | P54 to P50 |
| P53 | Speed at point 4 | Vel point 4 | P51 to P55 |
| P54 | Armature current at point 4 | Curr point 4 | P56 to P52 |
| P55 | Speed at point 5 | Vel point 5 | P53 to P57 |
| P56 | Armature current at point 5 | Curr point 5 | P58 to P54 |
| P57 | Reserved | Reserve | - |
| P58 | Reserved | Reserve | - |
| P59 | Reserved | Reserve | - |
| P60 | Reserved | Reserve | - |
| P61 | Reserved | Reserve | - |
| P62 | Reserved | Reserve | - |
| P63 | Reserved | Reserve | - |
| P64 | Reserved | Reserve | - |
| P65 | Reserved | Reserve | - |

| | | | |
|---|---|---|---|
| P66 | Armature current controller gain | P cur cntrlr | 0.01 to 1.00 |
| P67 | Armature current regulator time constant | I cur cntrlr | 0.0 to 300.0ms |
| P68 | Reserved | Reserve | - |
| P69 | Rated field current $\mathbf{I_{FNOM}}$ | Field ref | 1 to 1 600 |
| P70 | Armature voltage $\mathbf{Ua_{MAX}}$ at second operating mode entering | Voltage IIz | 100 to 450V |
| P71 | Field controller gain | P fld cntrlr | 0.01 to 4.00 |
| P72 | Field controller time constant | I fld cntrlr | 0.000 to 3.000s |
| P73 | Thermo sensor in power unit - enable / disable | Ena THERMO | 0, 1 |
| P74 | Threshold of **OC** protection – limit current $\mathbf{Idrv_{LIM}}$ of the converter | Prot OVRCURR | 0 to 270%$Ia_{NOM}$ |
| P75 | Time for $\mathbf{I^2t}$ protection switching on at $\mathbf{Ia_{MAX}}$**-OL** | Prot $I^2T$ | 1.0 to 60.0s |
| P76 | Threshold of speed $\mathbf{N_{LIM}}$ - **OS** protection | Prot OVRSPD | 0 to 110%$N_{MAX}$ |
| P77 | Minimum field current $\mathbf{I_{FMIN}}$ – **FL** protection | Prot FL min | 1 to 1 600 |
| P78 | Maximum field current $\mathbf{I_{FMAX}}$ - **FL** protection | Prot FL max | 1 to 1 700 |
| P79 | Field current $\mathbf{I_{FON}}$ when **ON** is switched off | Low field | 1 to 1 600 |
| P80 | Current feedback gain | Feedbck curr | 0.50 to 2.00 |
| P81 | Fine tuning of phase $\mathbf{L_1}$ | Fine tune R | 0 to 128 |
| P82 | Fine tuning of phase $\mathbf{L_2}$ | Fine tune S | 0 to 128 |
| P83 | Fine tuning of phase $\mathbf{L_3}$ | Fine tune T | 0 to 128 |
| P84 | Source of signal oriented stop | Source POS | 0, 1 |
| P85 | Type of speed feedback | Feedback | 0, 1 |
| P86 | Rotation speed of encoder at maximum speed of motor | Max ENC rpm | 0 to 20 000$min^{-1}$ |
| P87 | Direction during oriented stop | POS dir slct | -1, 0, 1 |
| P88 | First analog output **AOUT1** selection of variable | Analog OUT1 | 0 to 9 |
| P89 | Second analog output **AOUT2** selection of variable | Analog OUT2 | 0 to 9 |
| P90 | **OVERRIDE** enable / disable | Ovrride ENA | 0, 1 |
| P91 | **OVERRIDE** low limit | Ovrride LOW | 1 to 100% |
| P92 | **OVERRIDE** high limit | Ovrride HIGH | 101 to 200% |
| P93 | **OVERRIDE** actual value | Ovrride | - |
| P94 | Operation mode of **PF** protection | Trigger PF | 0, 1 |
| P95 | Maximum time for interruption of synchronization – **PF** protection | ENA time PF | 100 to 600 µs |
| P96 | Maximum permissible number of errors in synchronization - **PF** protection | ENA number PF | 6 to 150 |

**Table 4** Parameter list

**Note: Changing the parameters is performed in the following way:**

1) **When on parameter P15 the correct password (value 11) is entered and signal ENBL is INACTIVE – all parameters can be changed.**
2) **When on parameter P15 the correct password (value 11) is entered and signal ENBL is ACTIVE – only white-field parameters can be changed.**

| Error N | Meaning |
|---|---|
| **E07** | Error in nonvolatile memory operation |
| **E15** | Reserved number of parameter or inaccessible parameter in the relevant mode |
| **E17** | Failure situation – see **table 6.** |

**Table 5** List of errors observed on the specialized terminal

| LED | Failure mode description |
|---|---|
| **Constantly lightening LEDs** | |
| **FL** | The current in the field winding is out of reference limits |
| **TG** | Tacho protection switches on in first operating mode. Incorrect connection or interrupted circuit of tachogenerator. Incorrect **P14** parameter. |
| **OC** | Momentary exceeding limit current **Idrv$_{LIM}$** defined by the value of **P74** parameter of power unit of the converter. Programmable current protection appears. |
| **OS** | Exceeding of maximum reference speed **N$_{LIM}$** in parameter **P76**. |
| **OL** | Motor overload and **I$^2$t** protection switching on. |
| **PF** | Disconnected power and synchronization voltages or out of phase. Incorrect earthing of converter. |
| **FL, TG, OC, OS** | Failure in analog-digital converter |
| **LED s blinking in periods of 1 second** | |
| **TG** | Incorrect connection or interrupted circuits of encoder. |
| **OC** | Momentary exceeding of maximum permissible current **Idrv$_{MLIM}$** of converter power unit. Switching on of hardware current protection. |
| **OL** | Radiator thermo sensor switches on (at =1). |
| **LED s blinking in periods of 0.3 seconds** | |
| **FL** | Error in serial communication. (in RS 485 use) |
| **TG** | Tacho protection switches on in second operating mode. Failure of tachogenerator signal or high ripples. |
| **OS** | Error in nonvolatile memory operation. |

**Table 6** LED status in case of failure situation

## 7.3 Description of parameters

### 7.3.1 Group 1- signal measurement

Parameters from **P00** to **P08** are available in all operation modes.

Parameters **P07** and **P08** show digital inputs/outputs status by means of lightening of different display segments. When selecting these parameters the upper segments of all indicators light continuously. The correspondence between the lightening of a segment and digital input/output activation is shown on **table 7** and **fig. 15**.

Parameter **P10** show converter version.

Parameter **P16** shows indicated position errors while **ORCM** is operating.

| INPUTS | | OUTPUTS | |
|---|---|---|---|
| 4c-TLL | 2c-IN 6 | 4c- | 2c- |
| 4d-SR | 2d-IN 7 | 4d- | 2d- |
| 4e-SF | 2e-IN 8 | 4e- | 2e- |
| 4g-TLH | 2g-IN 5 | 4g-INPOS | 2g- |
| 3c-IN 10 | 1c-IN 2 | 3c-ZS | 1c- |
| 3d-IN 11 | 1d-IN 3 | 3d-SA | 1d- |
| 3e-IN 12 | 1e-IN 4 | 3e-RD | 1e- |
| 3g-IN 9 | 1g-IN 1 | 3g-TL | 1g- |

**Table 7** Correspondence between indication segments and relevant input /output

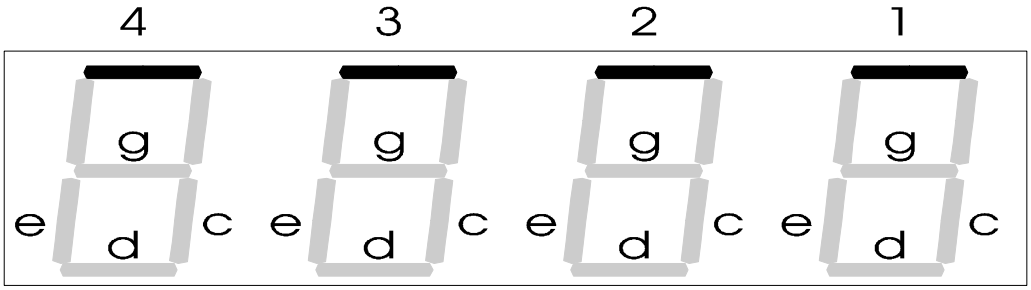



**Fig.15** Location of indication segments

### 7.3.2 Group 2 – System parameters

This group consists of two parameters.

- **P15** parameter – a password which enables changing of parameter values. The password is active until the switching off of the supply. When enter value **11** in parameter **P15**, the converter accepts the password and indicates value **1** on the terminal (access allowed).
- **P17** parameter – when entering value **1** in parameter **P17** the default values of all parameters are restored. The parameter could be changed when **ON** signal is inactive and the password is entered.

### 7.3.3 Group 3 – Speed control

The parameters are divided into 3 subgroups:

♦ **speed control**

- **P22** parameter – Ramp generator time. Defines the time for which the speed reference and the time for stop are reached;
- **P23** parameter – Speed $\mathbf{N_{ZS}}$ under which the **ZS** digital output switches on;
- **P24** parameter – Speed $\mathbf{N_{SA}}$ above which the **SA** digital output switches on;
- **P26** parameter – Change of speed feedback sign. It could be equal either to **0** or to **1**. When **P26**=1 the sign of the reference changes with no matter reference source selected by **P28;**
- **P27** parameter – Limit reference of maximum speed of the rotation;
- **P28** – Selection of speed reference source. It could have 4 values:

**0** - speed reference in parallel code of digital inputs **IN1** to **IN 12**;

**1** - speed reference from analog output $\mathbf{U_{REF}}$ in range from 0to + 10V or from 0 to -10V. The rotation direction depends of reference polarity. I these two cases the change of rotation direction is performed by means of **SR** and **SF**;

**2** - speed reference from analog input $\mathbf{U_{REFA}}$ in range from -10V to +10V;

**3** - speed reference by means of RS 232 C serial interface connected by **X6** connector. In this case control signal is entered as value of **P29** parameter. The parameter **P29** is not stored in the nonvolatile memory.

- **P85** parameter – feedback source selection:
  0 – tachogenerator;
  1 – encoder.

**Note: When P85 = 1 the ratio between motor and encoder must be constant.**

- **P86** parameter - speed of rotation of encoder at maximum speed of the motor and **P85**=1. The maximum frequency of the pulses in each line of the encoder is 220 kHz. When encoder is with 1024 rotations per minute the maximum rotation speed is 12890.6 rotations per minute. When encoder is with 2500 pulses per minute the maximum rotation speed is 5280 rotations per minute.

♦ **speed controller**

- **P25** parameter – speed reference offset;
- **P30** parameter – speed controller gain;
- **P31** parameter – speed controller time constant;
- **P33** parameter – "emergency stop" mode. It could have 3 values:

  **0** - When **ON** signal is disabled, the motor stops for a time period, defined by **P22** value and then the power rectifier is turned off;

  **1** - When **ON** signal is disabled, the motor speed reduces to zero speed quickly and then the power rectifier is turned OFF;

  -1 - When **ON** signal is disabled, the power rectifier of the converter switches off and the motor stops by floating.

♦ **position oriented stop**

- **P20** parameter – offset of speed reference at **ORCM**. Together with parameter **P16** (indicating position errors while **ORCM** is operating) **P20** allows the reference position to be set with accuracy.
- **P34** parameter – number of pulses in one rotation of the encoder;
- **P35** parameter – offset of reference position;
- **P36** parameter – permissible variation of reference position with switching of digital output **INPOS** in oriented stop. The parameter **P36** defines the accuracy of reference position performance;
- **P37** parameter – equalizing of direction of both motor rotation and encoder rotation by means of change of phase sequence of the encoder. It could have tow values:

  **0** - positive sequence;

  **1** - negative sequence.
- **P38** parameter – ratio between spindle speed of rotation and encoder speed of rotation;
- **P39** parameter – position reference in oriented stop. The oriented stop in position defined by parameter **P39** is performed when **P84**=0. When **P84**=1 oriented stop is performed in position defined by means of parallel code of digital inputs **IN1** to **IN12**;
- **P40, P41, P42** parameters serve for setting of controller in position whose algorithm is performed in the following method:

$$U_n = U_{n-1} * P40 + P41 * f(P42 * \varepsilon) + P20$$, **where:**

$U_n$ – position controller output value,

$U_{n-1}$ – position controller output value from the previous calculation,

$\varepsilon$ – position error.

- **P84** parameter – selection of position reference source. It could have two values:

  **0** – the position reference is defined by the value of **P39** parameter;

  **1** – the position reference is defined by parallel code of digital inputs from **IN1** to **IN12**;
- **P87** parameter – direction of entering in position in oriented stop. It could have 3 values:

  **0** – keeps the direction of rotation;

  **+1** – clockwise;

  **-1** – counterclockwise.

### 7.3.4 Group 4 – current control

The parameters are divided into three subgroups:

♦ **armature current control**

- **P43** parameter – rated current of the motor $\mathbf{Ia_{NOM}}$ – defined in percents from rated converter current $\mathbf{Idrv_{NOM}}$, according **table 1;**
- **P44** parameter – maximum current of the motor $\mathbf{Ia_{MAX}}$ – defined in percents from rated current of motor $\mathbf{Ia_{NOM}}$;
- **P45** parameter – maximum current $\mathbf{Ia_{TLH}}$ that limits motor current in active signal **TLH** defined in percents towards the rated current of motor $\mathbf{Ia_{NOM}}$;
- **P46** parameter – maximum current $\mathbf{Ia_{TLL}}$ that limits the motor current in active signal **TLL** defined in percents from the rated current of the motor $\mathbf{Ia_{NOM}}$;
- **P66** parameter - armature current controller gain
- **P67** parameter – armature current controller time constant

♦ **speed dependent current limit**

- **P47 to P56** parameters – they define the points of the speed – dependent current limit curve.

All these parameters are accessible only when signal **ON** is inactive and password is entered. When entering these parameters it is necessary to observe the following rules:

The pointes of the speed-dependent current limit curve are located in the range of motor speed from 0.25 $\mathbf{N_{MAX}}$ to $\mathbf{N_{MAX}}$ and in the range of current from 0.25 $\mathbf{Ia_{MAX}}$ to $\mathbf{Ia_{MAX}}$ (**P44**). An example of the parameters of speed dependent current limit curve is shown on **table 8** and **fig. 16**. Point **1** of speed dependent current limit curve defines the limit speed $\mathbf{N_{L1}}$ of motor operation at $\mathbf{Ia_{MAX}}$ and this point is defined of parameter **P47**. Each next point must be defined of speed that is 1% higher than the previous point and current - at least 1% lower than the current of the previous point. In case of correction each point could be moved till speed that is at least 1% lower than the next point and current – at least 1% higher.

| **Parameter** | **P44** | **P50** | **P52** | **P54** | **P56** | **P48** |
|---|---|---|---|---|---|---|
| $\mathbf{Ia_{MAX}}$ **%** | 200 | 160 | 125 | 110 | 103 | 100 |
| **Parameter** | **P47** | **P49** | **P51** | **P53** | **P55** | **-** |
| $\mathbf{N_{MAX}}$ **%** | 25 | 40 | 60 | 75 | 90 | 100 |

**Table 8 Table - e**xample of speed dependent current limit curve parameters

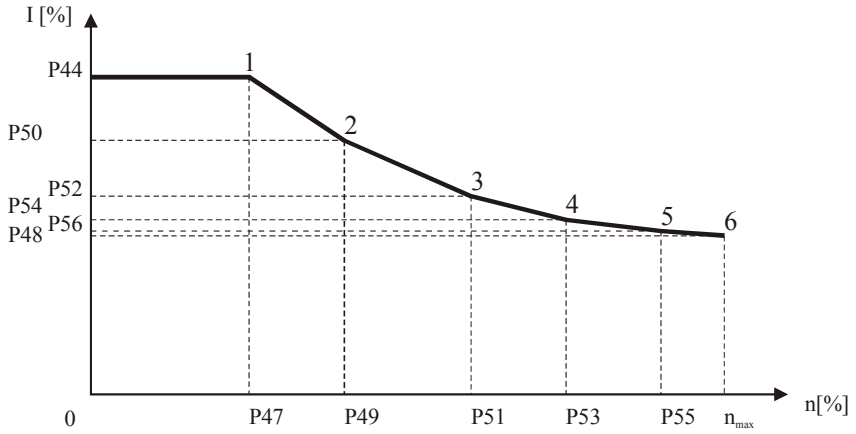



**Fig. 16** Diagram - example of speed dependent current limit curve parameters

♦ **field current controller**

- **P69** parameter – reference of rated field current of motor $\mathbf{I_{FNOM}}$ in dimensionless units. The maximum number of dimensionless units corresponds to maximum filed current $\mathbf{Idrv_{FM}}$ of the converter, shown in **table 1**.
- **P79** parameter – reference of field current of motor $\mathbf{I_{FON}}$ in dimensionless units when signal **ON** is disabled. The maximum number of dimensionless units corresponds to maximum field current $\mathbf{Idrv_{FM}}$, shown in **table 1**. The field current $\mathbf{I_{FON}}$ is turned 10s after signal **ON** is disabled. At field current $\mathbf{I_{FON}}$ the heating of the non-operating motor is decreased;
- **P71** parameter- field current controller gain;
- **P72** parameter – time constant of field current controller.

### 7.3.5 Group 5 - protections

- **P14** parameter – the protection of speed feedback loss in first operating mode - motor armature voltage, lower than the value of **P70** parameter. The protection compares together the voltage of speed feedback sensor with the voltage of motor armature regarding their values and signs. Parameter **P14** scales the motor armature voltage for the corresponding actual speed, equalizing this voltage with the voltage of feedback sensor for the same speed. The running error in protection setting is shown as **P13** parameter value. By changing the value of parameter **P14** the absolute value of **P13** is minimized. When the protection is set this absolute value must be almost zero. In proportional mode when P19=1 the protection is switched off.
- **P73** parameter – **OL** protection of converter power unit overheating. The operation of this protection is allowed by parameter **P73**=1. The **OL** protection switches on when **P73**=1 and when converter power unit thermo sensor switches on (see **table 6**);
- **P74** parameter – Maximum permissible momentary current $\mathbf{Idrv_{LIM}}$ in converter power rectifier, defined in percents from the rated current of motor $\mathbf{Ia_{NOM}}$. When the current is higher than $\mathbf{Idrv_{LIM}}$ the programmable current protection **OC** switches on. In failure mode when current in power rectifier is higher than the maximum limit current $\mathbf{Idrv_{MLIM}}$ the hardware current protection **OC** switches on and the LED indication operates in blinking mode with duration of blinkings of 1second. Maximum limit current $\mathbf{Idrv_{MLIM}}$ is defined for power devices of every type of converter and it is set by manufacturer;
- **P75** parameter- time of $\mathbf{I^2t}$ overload protection switching on at maximum current of motor $\mathbf{Ia_{MAX}}$. The protection begins to measure the overload at motor current values higher than rated current of the motor $\mathbf{Ia_{NOM}}$. When the protection switches on the **OL** LED starts lightening;
- **P76** parameter – Maximum limit speed of motor rotation $\mathbf{N_{LIM}}$. When the speed of rotation of the motor is higher than $\mathbf{N_{LIM}}$ the **OS** protection switches on.
- **P77** parameter – minimum permissible field current $\mathbf{I_{FMIN}}$. When field current is lower than $\mathbf{I_{FMIN}}$ the **FL** protection switches on;
- **P78** parameter – maximum field current $\mathbf{I_{FMAX}}$. When filed current of the motor is higher $\mathbf{I_{FMAX}}$ the **FL** protection switches on.

### 7.3.6 Group 6 – configuration parameters

- **P19** parameter – speed and current controllers switching off. When **P19=1** the converter operates in proportional mode, and thyristor firing angle reference is internal-limited in safe values. When **P19=0** the converter operates in integral mode. When switching on the converter the value of **P19** is 0. The change of **P19** is not recorded in the non-volatile memory;
- **P70** parameter – maximum voltage of armature of the motor;
- **P80** parameter – current feedback gain of the motor;
- **P81** parameter – $\mathbf{L_1}$ phase fine tuning;
- **P82** parameter – $\mathbf{L_2}$ phase fine tuning;
- **P83** parameter – $\mathbf{L_3}$ phase fine tuning;
- **P88** parameter – selection of variable for first analog output **AOUT1**. See table 9.
- **P89** parameter – selection of variable for second analog output **AOUT2**. See table 9.

| **P88** and **P89** parameters | **Active signal of analog outputs** |
|---|---|
| 0 | Absolute actual value of armature of the motor. Analog output range from 0 V to 10 V corresponding to the motor current change from 0% to100% **I** $\mathbf{a_{MAX}}$ |
| 1 | Absolute actual value of motor speed rotation. Analog output range from 0% to 100% $\mathbf{N_{MAX}}$ |
| 2 | Actual speed of motor rotation. Analog output range from -10V to +10V in connection with the change of the speed from -110% $\mathbf{N_{MAX}}$ to +110% $\mathbf{N_{MAX}}$. |
| 3 | Speed reference before the rampgenerator. Analog output range from -10V to +10V, corresponding to reference change from -100% to +100%. |
| 4 | Speed reference after the rampgenerator. Analog output range from –10 V to +10 V , corresponding to reference change from –100 % to +100 %. |
| 5 | Voltage of motor armature. Analog output range from –10 V to +10 V corresponding to voltage change from – 600 V to + 600 V. |
| 6 | Actual field current of motor. Analog output range from 0V to 10 V, corresponding to current change from 0 to $\mathbf{I_{FMAX}}$ |
| 7 | Current reference at speed controller output. Analog output range –10 V to +10 V, corresponding to current reference change from $\mathbf{-Ia_{MAX}}$ to $\mathbf{+Ia_{MAX}}$. |
| 8 | Current reference after current limit. Analog output range from –10 V to +10 V, corresponding to current reference change from $\mathbf{–Ia_{MAX}}$ to $\mathbf{+Ia_{MAX}}$. |
| 9 | Thyristor firing angle reference on current controller output. Analog output range from –10 V to +10 V, corresponding to maximum values of the reference for thyristor firing angle. The sign of the reference determines the polarity of armature voltage. |

**Table 9** Selection of variable for analog outputs

- **P90** parameter – **OVERRIDE** function enabled. It is accessible for changes only when **ON** signal is inactive. It could have 2 values:
  **0** – **OVERRIDE** function enabled;
  **1** – **OVERRIDE** function disabled.

The digital realization of **OVERRIDE** function when **P28**= [1, 2] is explained in details in item 5.1.1. The analog realization of **OVERRIDE** function when **P28**=0 is explained in details in item 5.2.1.

- **P91** parameter – low limit of **OVERRIDE** value. The parameter is accessible only when **ON** signal is inactive;
- **P92** parameter – high limit of **OVERRIDE** value. The parameter is accessible only when **ON** signal is inactive;
- **P93** parameter- **OVERRIDE** actual value. It is read-only;
- **P94** parameter – **PF** protection operation mode. Parameter **P94** could have two values:

  **0** – in this mode the if **PF** protection is active it is for information purpose only and the converter does not switches off;

  **1** – in this mode when the if **PF** protection is active, the converter switches off. The converter operation could begin again after **ON** command.
- **P95** parameter – time duration of the period during which the synchronization pulse is expected. When the synchronizing pulse is out of this period an error is recorded. These errors also are included in the error counter of **PF** protection. When the content of the counter reaches the value of **P96** parameter the **PF** protection switches on;
- **P96** parameter – maximum number of errors in synchronization till **PF** protection switching on.

## 7.4 Error indication

Besides the information for the parameters, the information for errors of converter operation is shown on the display too. The **EXX** message means indication for error whose number is shown in the last two digits. The error indication appears when the error is registered with no matter of converter operation mode and without further actions of user to be needed. When push the **ESC** button the terminal status preceding the error is restored.

# 8 Connection and setting of the converter

It is performed on few stages by means of the following devices:

- Voltmeter ranging up to 500 V $_{AC/\,DC}$, class 1.5;
- Digital tachometer;
- Ampere meter ranging up to +/-10 $A_{DC}$, class 1.5;
- Oscilloscope;
- The **ON** button for selection of input/output interface of **X1** connector;
- Setting parameter terminal.

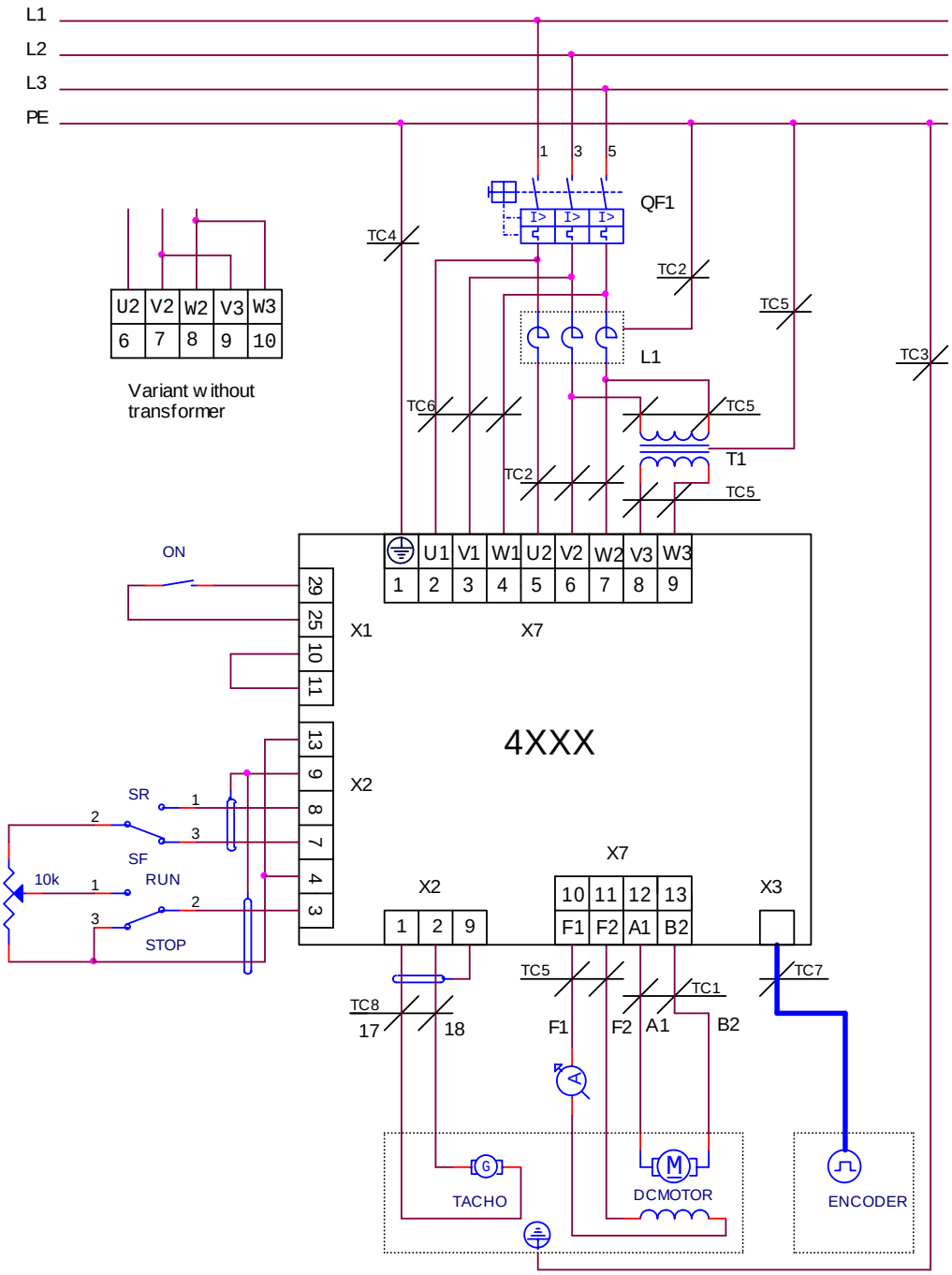



**Fig.17**. Scheme of connection and setting of the converter.

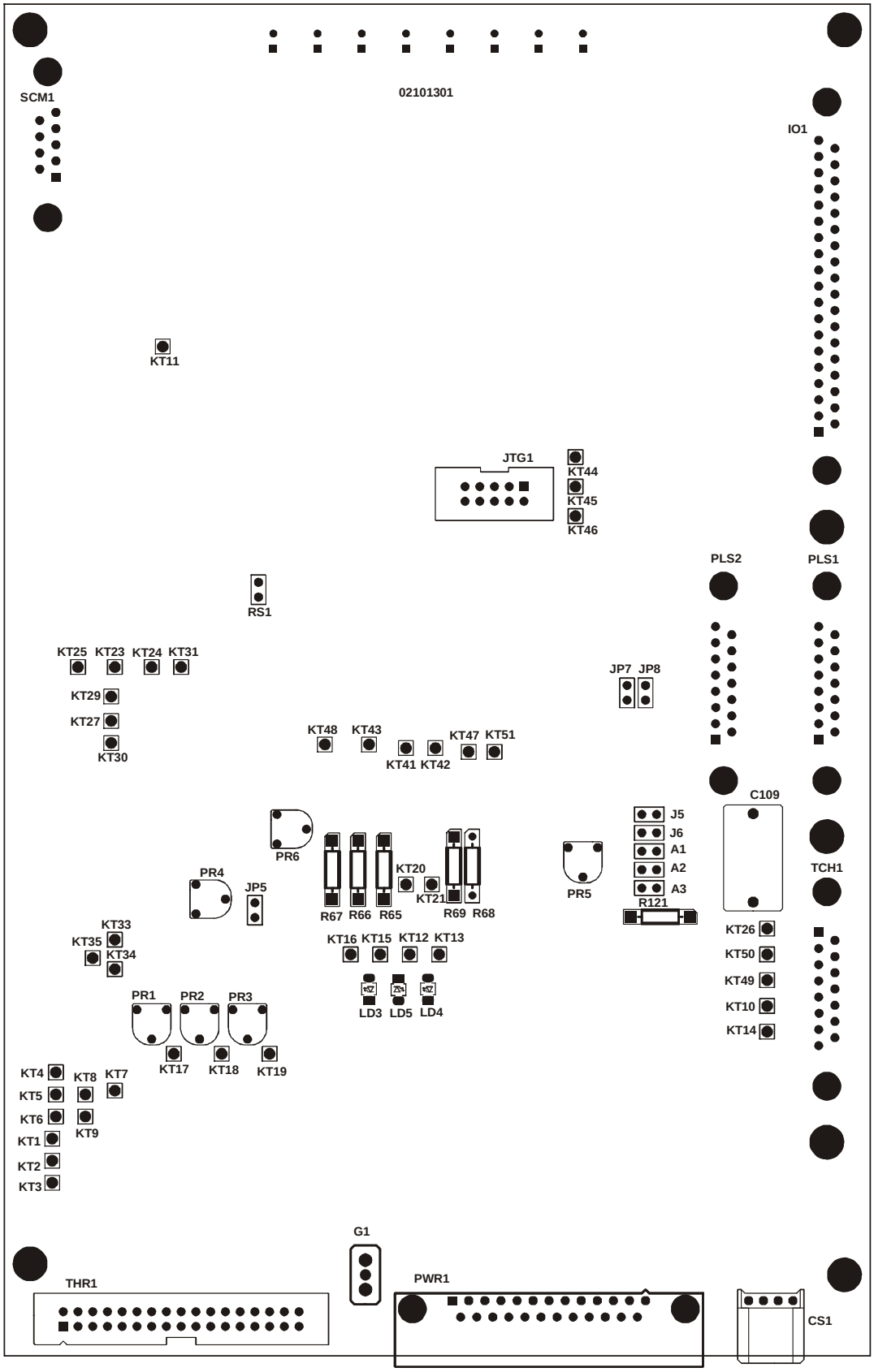



**Fig.18**.Main board – position of the elements used for setting

## 8.1 Supply voltage test

Operative voltage (**U1, V1** and **W1**) and supply voltage (**U2, V2,** and **W2**) are connected to the converter according to the scheme shown on **fig. 17.** During this test the motor is not connected to the converter.

The specialized terminal for parameter setting is connected to **X6** connector of the converter.

If after the converter is supplied by the supply voltage and operative voltage, the **PF** LED keeps lightening the following test must be performed: The voltage between the terminals 2 and 5 (marked as **U1** and **U2**) is measured. If they are connected correctly the voltage between them must be almost 0V. In case that the voltage between them is equal to 380 V, this means that there is a mistake in connection. The voltage must be switched off and then the mistake to be cleared. The same procedure must be repeated for all pair terminals – 3 and 6 (marked as **V1** and **V2**) and 4 and 7 (marked as **W1** and **W2**). The sequence of the phases does not matter and it is determined automatically by the converter. The **T1** transformer performs galvanic-isolation of the field winding of the motor from the supply mains. By this transformer the voltage between the field winding and compensation winding is decreased and this way the possibility of electrical rupture between them is decreased. It is recommended especially for used up motors. When selecting **T1** transformer it is necessary to take into consideration the supplying of rated voltages and current to the field winding of the motor.

### Attention:

**The primary winding of the transformer must be connected to V2 (X7.6) and W2 (X7.7) terminals while the secondary winding must be connected to terminals marked as V3 (X7.8) and W3 (X7.9) as shown on fig. 17.**

**The scheme of connection of motor field winding directly to the mains is shown on fig.17.**

After finishing this test the converter supply is switched off.

## 8.2 Initial converter setting

### 8.2.1 Preliminary setting of speed feedback

- Speed feedback with tachogenerator

The converter is set for operation with tachogenerator - **P85**=0 by default.

The voltage of the tachogenerator at maximum rotation speed is calculated by the following formula:

$$\mathbf{Ubr_{MAX} = (N_{MAX} / 1000) * Ubr_{1000}},$$ where:

$\mathbf{N_{MAX}}$ – maximum motor speed;
$\mathbf{Ubr_{1000}}$ – tachogenerator voltage at 1000 $min^{-1}$

By the maximum voltage of tachogenerator calculated in this way the range from **table 2** is selected. The protective cover of the main board must be taken off and the jumpers **J5, J6, A1, A2,** and **A3** must be put in the corresponding combination selected from **table 2**.

- Speed feedback with encoder

Turn the power supply on and **P00** appears on the display of the specialized terminal. Select the password by the way explained in item **7.3.2**. Enter the values of the parameters that concern directly encoder operating as speed feedback sensor:

- **P85** parameter – the encoder is selected to be speed feedback sensor by entering value **1**;
- **P34** parameter - the number of the pulses for one rotation of the encoder are entered;
- **P86** parameter – the speed of encoder rotation at maximum motor speed is entered;

### 8.2.2 Setting of motor parameters

The values of the parameters that concern directly the maximum permissible and operative parameters of the motor are entered:

- **P43** parameter – rated armature current of motor $\mathbf{Ia_{NOM}}$;
- **P44** parameter – maximum armature current of motor $\mathbf{Ia_{MAX}}$;
- **P47** to **P56** parameters –speed dependent current curve of the motor;
- **P70** parameter - armature voltage of motor $\mathbf{Ua_{MAX}}$ in second operation mode entering;
- **P69** parameter – rated field current of motor $\mathbf{I_{FNOM}}$. When converter is switched on for first time a low value of parameter **P69** must be entered – for example **P69**=200. The value selection of **P69** is explained in details in item 8.3;
- **P79** parameter – motor field current $\mathbf{I_{FON}}$ at signal **ON** is inactive**.** In initial starting of the converter the value that must be entered in parameter **P79** must be equal to the value of **P69** parameter. The value selection of **P79** is explained in details in item 8.3;
- **P77** parameter – minimum field current $\mathbf{I_{FMIN}}$ that switches on **FL** protection. When converter is switched on for first time the value of **P77** must be default value. The value selection of **P77** is explained in details in item **8.3**;
- **P78** parameter – maximum field current $\mathbf{I_{FMAX}}$ that switches on **FL** protection. When converter is switched on for first time the value of **P78** must be default value. The value selection of **P78** is explained in details in item 8.3;

## 8.3 Setting of rated, maximum and minimum field currents of motor

The power supply must be switched off. Connect the motor to the converter. An amperemeter ranging of 10 $A_{DC}$ must be connected successively to the electric circuit of the field winding.

Turn again the supply on. The **ON** signal is inactive. The field current of the motor must be checked by means of the ampermeter while the **ON** signal is not active.

By means of parameter **P69** the field current of the motor must be changed until reaching its rated values $\mathbf{I_{FNOM}}$ corresponding to the concrete motor. During every change of the value of **P69** the field current $\mathbf{I_{FON}}$ is determined automatically from parameter **P69** during about 8-10sec and it is checked by the ampermeter. After this time period when ON signal is inactive, the field current is defined by parameter **P79**. The value of parameter **P69** must be higher or equal to the value of **P79** parameter. The features of field current $\mathbf{Ia_F}$ in relation with parameters **P69** and **P79** is almost linear.

If during the setting process the value of parameter **P69** is higher of 1500 units it is necessary the **R69** resistor (on high assembling of processor board – fig. 18) to be decreased (or shunted). Resistor **R69**=47 Ω/0.25 W is assembled by manufacturer. Respectively if the value of parameter **P69** is less than 300 units it is necessary the value of resistor **R69** to be increased, but values higher than 120Ω are not recommended.

After setting the rated field current $\mathbf{I_{FNOM}}$, the field current $\mathbf{I_{FON}}$ when **ON** signal is inactive, must be determined by means of **P79** parameter. The recommended values are in the range from 50 to 100% from the value of parameter **P69**.

In order to avoid the switching on of **FL** protection during settings it is necessary to observe the following:

- minimum field current $\mathbf{I_{FMIN}}$ (low limit of **FL** protection), defined by parameter **P77** must have value equal to about 20% from the field current $\mathbf{I_{FON}}$ when **ON** signal is inactive;
- maximum field current $\mathbf{I_{FMAX}}$ (high limit of **FL** protection), defined by parameter **P78** must have value equal to more than 130% from the rated field current $\mathbf{I_{FNOM}}$ defined by parameter **P69**.

After specifying the values of **P69** and **P79**, the value of parameter **P78** must be defined between 120% and 130% from the value of parameter **P69**. The value of parameter **P77** normally is 50-80 units.

If rated field current $\mathbf{I_{FNOM}}$ is not known, but only the voltages of the field winding $\mathbf{U_{FNOM}}$, the field current must be defined in the following way:

- the active resistance of field winding at indoor temperature must be measured;
- the value of the measured resistance must be multiplied with coefficient of **1.2** in order to calculate the resistance $\mathbf{R_F}$ of the winding when the motor is heated;
- the field current $\mathbf{I_{FNOM}}$ must be calculated by means of the following formula:

$$\mathbf{I_{FNOM} = U_{FNOM} / R_F};$$

- the setting of the other parameters concerning motor excitation must be performed in the sequence described here above.

## 8.4 Proportional mode operation

The first putting in operation of the converter together with a motor must be made in proportional mode. In this mode the controllers of speed and of armature current are switched off and do not influence converter operation, i.e. the motor could operate with low speed with tachogenerator/encoder not switched on or with tachogenerator/encoder out of phase. The protection of speed feedback loss is switched off. During proportional mode of operation tachogenerator test, fine tuning of speed feedback loop and operation test of all thyristors are performed.

The starting of proportional mode could be performed by entering of value **1** in parameter **P19**. The change of parameter **P19** is not stored in the nonvolatile memory and every time when the converter is switched on the value of this parameter is equal to **0** e.g. the converter operates in integral mode. In proportional mode the speed reference source defining the thyristor firing angle is selected by parameter **P28** and the reference is internal limited to safe value.

The signal ON is enabled and the motor starts turning.

The relative value (in %) of maximum tachogenerator voltage referred to the average value during a period of approximately 1 sec could be shown by parameter **P12**. When the tachogenerator is in good operational condition, in relevant mode the value of **P12** must not exceed 2%. When the value of **P12** is higher than 2% a repair of tachogenerator must be made.

For testing the correct connection of the tachogenerator the values of parameters **P01** and **P05** must be compared. When the tachogenerator is connected correctly the values of both parameters must have the same signs. In case the values of both parameters have different signs the following two cases are possible:

- the direction of motor rotation is according to the reference. The connection of the tachogenerator must be changed;
- the direction of motor rotation is opposite to the reference. The connection of the motor armature must be changed.

When an encoder is used for speed feedback sensor the test of its correct connection is performed by comparing the values of parameters **P01** and **P05**. When the encoder is connected correctly the both parameters must have the same signs. If the values of these two parameters have different signs the following two cases are possible:

- the direction of motor rotation is according to the reference. The value of parameter **P37** must be changed;
- the direction of motor rotation is opposite to the reference. The connection of the motor armature must be changed.

The fine tuning of speed feedback channel is also performed in proportional mode. By changing the firing angle of the thyristors by parameter **P28** the defined speed of rotation is selected (for example 10% from $\mathbf{N_{MAX}}$) with the digital tachometer. By means of trimmer potentiometer

**RP5** the (see fig. 18) the values of **P01** (turned from % in speed) and of the tachometer are equalized.

For testing the operation of the thyristors from the power rectifier of the converter, the shape of the armature current in p. **KT20** is observed by means of oscilloscope. The signal **ON** is activated. A speed of rotation that is not very big for example 5% from $\mathbf{N_{MAX}}$ must be recorded and the shape of the motor armature current of main board is checked by means of oscilloscope control point KT 20 of the main board. The observed pulses of armature current must be in interval of 3.3ms and the difference of their amplitude must not be more than 20%. The direction of motor rotation is changed and then again the armature current of motor must be checked. If there is any diversion (missing pulses or big difference in their amplitude) diagnostics must be performed in order to eliminate the reason for the inconformity. The probable reason for the missing pulses could be the missing of controlling pulses in a thyristor – the circuits of pulse transformers and power unit must be checked. When the difference in the amplitudes is very big, the values of **P81**, **P82** and **P83** must be checked (fine tuning of phases $L_1$, $L_2$, $L_3$).

## 8.5 Setting of protection of speed feedback loss

The protection of speed feedback loss does not operate in proportional mode. In this mode only its setting is performed.

The protection is set by parameter **P14**. The running error of the protection setting is the value of **P13**. The setting must be done successively for the different increasing rotation speeds.

By changing the firing angle of the thyristors is defined maximum speed of rotation of the motor in proportional mode, but not higher than the rated speed of rotation. The parameter of **P14** is changed till the running error shown in parameter **P13** to reach its smallest possible absolute value.

The direction of the rotation is changed by changing the sign of the angle reference. If motor and feedback sensor are in good operation condition, the running error of the protection in **P13** must be almost equal to the error in the other direction of rotation.

When there is big difference in the running error in both directions the neutrals of the motor and of the tachogenerator or the condition of the encoder.

**Attention:**

**After every maximum speed scaling (by RP5 turning or by different combinations among A1, A2, A3, J5 and J6 jumpers – see fig.18) it is necessary to minimize the absolute value of parameter P13 (in a first operating mode only) by the appropriate change of P14.**

## 8.6 Testing of converter operation in integral mode

After the above mentioned procedures are fulfilled, ON signal is inactivated. Write 0 in **P19** parameter to switch on the operation in integral mode Select a value of **P22** (rampgenerator time) in relation with the wished dynamic of the electrical drive and inertia mass. At big values of **P22** the motor operates with small acceleration.

The signal **ON** is activated and the speed of rotation is increased slowly and during this time the armature voltage (**P05**) and the field current (**P06**) are checked, in order to find the voltage at which the field current begins to decrease (motor in second operation mode). If the motor does not goes into the second operation mode the correct connection of field winding must be checked according fig. 17. ($L_1$ phase must not be used).

For exact calibration of speed feedback a speed reference of 50% from $\mathbf{N_{MAX}}$ must be entered to the motor and by means of **RP5** the referred speed, measured with the tachometer is reached.

The final setting of the protection from speed feedback loss is made. Rotation speed in first operating mode is referred, for example 80% from rated motor speed and by means of the relevant changing of **P14** the absolute value of **P13** is minimized.

After finishing with the settings and in case there is higher level control device (CNC) a controlling interface is connected to the converter. After that the converter is tested in all operation modes. If all requirements are fulfilled the machine is ready for operation. The supply voltage is switched off and the converter is closed.

If the converter operation is not satisfactory the current and speed loops of the converter must be set.

The supply is switched off. The motor is on no load and also disassembly from the machine.

The supply is switched on and by means of parameter **P15** the password is entered in the way explained in item 7.3.2. The parameter **P22** is entered zero value. The signal **ON** is activated.

Leap speed reference is entered, close to the rated speed and on the oscilloscope the shape of the armature current in control point **KT 20** is observed. If there is high overshoot displayed on the oscilloscope (high current pulses shown at the begining of the oscillogram) you must check **P66** and **P67** values. After that zero speed is referred by leap the shape of the armature current is observed again.

After setting the current controller the same procedure must be repeated for the speed loop – by oscilloscope in control points **KT 26** the tachogenerator voltage is observed. It is permissible a one-time jump of the speed that does not exceed the relevant values with more than 5%. If there is fluctuation in the speed and big presetting – the values of parameters **P30** and **P31** must be checked.

After finishing the above mentioned procedures the value of parameter **P22** is set in the wished dynamic of the electrical drive and the inertia mass.

In this way converter drive system setting is completed.

**Attention!**

**The measurement of all signals must be done in reference with KT 16 common.**

**All tachogenerator pin indications of the motor on fig. 17 correspond to motor indications, manufactured by DYNAMO SL Company situated in the town of Sliven. F1 and F2 mark the beginning point and the ending point of the field winding, A1 marks the armature winding beginning point and B2 - compensating winding ending point.**

**All setting elements of the field current, armature current and motor maximum speed are placed on the main control board (See fig. 18)**

# 9 Rated armature current range setting

When a motor with rated armature current significantly lower than the rated current of the motor is used (with more than 25%) setting of rated converter current must be made. The converter keeps its operation features in **table 1**.

The rated current **$Idrv_{NOM}$** of the converter is defined by means of **R 65, R66** and **R67** resistors, connected in parallel. **See fig.18**. The equivalent resistance value for the rated current **$Idrv_{NOM}$** selected is:

$$Re = 670 / Idrv_{NOM}, \quad \text{where}$$

**Re - equivalent resistance [Ω]**
**$Idrv_{NOM}$ – rated converter current [A]**

**The power of the resistors must not be less than 0.25W.**
For **Re** values lower than 20 Ω three resistors must be used.
For **Re** values higher than 20 Ω two resistors could be used.

**For example:**
For **$Idrv_{NOM}$** = 30 A, **Re** = 670 / 30 = 22.3 Ω. Resistors **R65**=**R66**=45 Ω. Resistor **R67** is not connected.
For **$Idrv_{NOM}$** = 64 A, **Re** = 670 / 64 = 10.47 Ω. Resistors **R65**= **R66**= **R67**= 33 Ω.

# 10 Possible failures and relevant failure clearing methods

| Situation | Possible reason | Check-up methods and eliminating the problem |
|---|---|---|
| 1. When supplying protection PF is activated | Phase failure or synchronizing and power supply out of phase | Check power and operative supply for availability, phase coincidence and quality of the connections.<br>Check grounding and. If there is blinking protection check the connection quality in power supply. |
| 2. When switching the drive system on and ON signal enabled the current breaker turns on | Rupture in thyristors or short circuit in power unit | Disconnect connections power supply and motor armature. Check between U2, V2, W2 terminals and A1 by means of ohmmeter. After that check between the terminals and B2. |
| 3. After switching the drive system on, FUT or FUS fuses blew | Rupture in thyristors, short circuit in field unit or short circuit in motor winding | Replace the module that has failed.<br>Do diagnostics and repair. |
| 4. After switching the drive system on, ON signal is enabled, the reference increases slowly, FUT and FUS fuses blew | Short circuit between field and motor armature. It occurs in case of supply without transformer of the field | Check the insulation resistance between field circuit and armature circuit by means of an ohmmeter. If the measured value is less than 2 MΩ, the motor must be repaired. |
| 5. When ON signal is enabled and the peculiat motor growling is heard in one of the rotation directions in transient mode. | There are “missing“ armature current pulses | Check armature current pulses on KT20 control point by means of an osciloscope. Compare them with the measured current pulses from R1 to R 12 resistors in order to find “missing“ thyristor. Check also its gate circuit and the thyristor itself. |
| 6. When ON signal is enabled and speed reference is entered, the motor speed “fluctuates” | There is a shunt in motor armature or in tachogenerator | The device is starting in a proportional mode(P19=1)<br>The motor starts driving as a “step” motor. ON signal is inactive and if a field current is indicated, the motor shaft is rotating by hand. If the resistance moment increases in definite zones it means that there is a shunt in motor armature. |
| 7. When therespeed reference over rated are entered the drive does not fulfill them and OC protection becomes active | The converter drive system does not operate in second zone- constant power mode (field weakening) | Check P70 values. Check if P05 measures correctly the armature voltage. Check power lines that feed the field module (do not use R power line) |
| 8. When motor starts running at low speed after it was repaired, there are field current deviation and FL becomes active | Low quality repair of the motor. | Check the connection of the additional poles and compensation winding of motor. |
| 9. After starting the device TG protection activates at lower motor speed | Feedback lost or it is out of phase or speed feedback is not scaled properly | Check connecting of tachogenerator and its good working condition.<br>Check P13 and P14 parameters.<br>Check tachogenarator calibration. |

| | | |
|---|---|---|
| 10. After starting the drive and speed reference in second operating mode TG protection becomes active (TG led is flicking in 0,2 second periods) | Tachovoltage overripple content | Check P12 value during the working process. If P12 values are higher than 5 % tachogenerator must be repaired |
| 11. After ON signal is active FL protection become active | Parameters chosen by the operator are wrong | Compare two parameters- P69 value with P78 value. If necessary P78 value should be increased 130 % from P69 value at least. |
| 12. After ON signal is active and speed reference close to max. motor speed than FL protection becomes active | Parameters chosen by the user are wrong | Compare two parameters – P69 and P77. If necessary P77 value to be reduced not less than 5% from P 69 value. |
| 13. After ON signal is active and speed reference close to max. motor speed than OS protection becomes active | Overspeed | Check P76 value. |
| 14. While drive is operating OL protection becomes active | Overloaded motor | Check operating modes of the machine. If necessary replace with more powerful drive system. Check also P75 parameter value |
| 15. While device is working OL protection becomes active and OL led blinks at time periods each 0.5 seconds long . | Overheated power block | Turn the converter OFF and cool it. Provide power block of the converter with better ventilation. |
| 16. After ORCM signal on TG protection is activated and TG led blinks at time periods each 0.5 seconds long | Position feedback lost | Check all encoder electrical circuits for correspondence and availability. |

1